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CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

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VOL. VII · NO. 1

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E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

AVRIL 1932

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IMPRIMERIE BIANCO LUNO A/S

An Improved Type of Current-Meter.

By

V. Walfrid Ekman, Lund.

In connection with preparations for an oceanographical expedition, organized in cooperation with B. Helland-Hansen, I have endeavoured to construct an improved current-meter on the same principles as an instrument which was already supplied 27 years ago by the Central Laboratory at Christiania[1]). The velocity of the current is calculated in the usual way from the number of revolutions of a "screw" or gauge wheel after the pattern of a screw propeller; and the direction of the current is repeatedly recorded by means of bronze balls dropped from the south end of a compass-needle down into numbered sectorial compartments at the bottom of the compass-box. The measurement is begun on the arrival of a messenger and is finished on the arrival of a second one.

Some years ago the writer invented on the same principles a larger instrument, the "Repeating Current-Meter", with 47 messengers, for the purpose of taking at one haul a large number of consecutive, complete current-records[2]). On the above-mentioned expedition this instrument proved to be invaluable for the investigation of currents at several hundred metres below the surface. But for investigations in the upper water-layers a less complicated and more easily handled single-record instrument is sufficient. As the result of successive improvements of the Central Laboratory type, Alfred Merz has described two such instruments[3]), differing slightly, one for weak or moderate currents and one specially for very strong ones up to 3 metres per second.

[1]) V. Walfrid Ekman. Kurze Beschreibung eines Propell-Strommessers, Publ. de Circons. No. 24. Copenhague 1905.

[2]) V. Walfrid Ekman. On a New Repeating Current-Meter, Publ. de Circons. No. 91, Copenhague 1926.

[3]) Alfred Merz. Stark- und Schwachstrommesser. Veröffentl. des Inst. für Meereskunde, N. F., Reihe A, Heft 7, Berlin 1921.

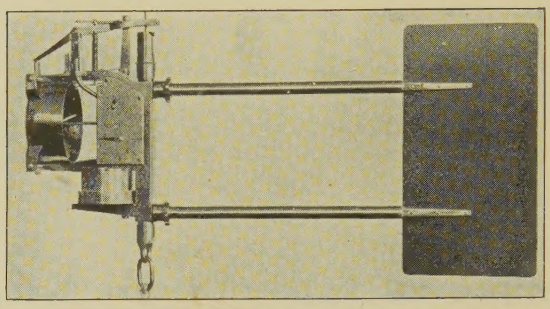

Fig. 1.

In the new instrument here described — which may be called the "Protected Current-Meter" — I have used some of the characteristic features of the MERZ current-meter; but it cannot replace the strong-current type of the latter instrument. The alterations from the original

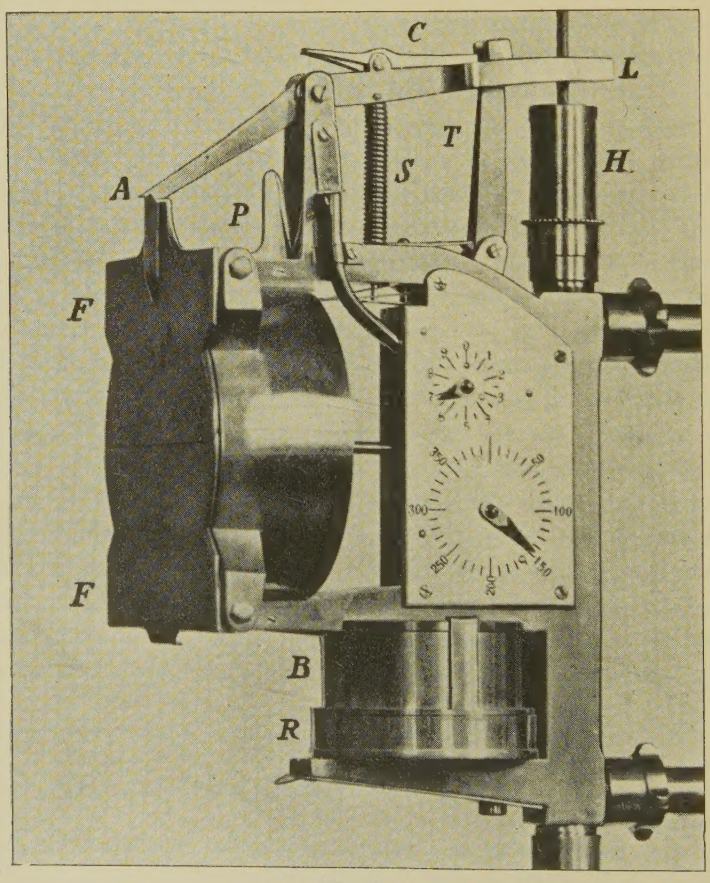

Fig. 2.

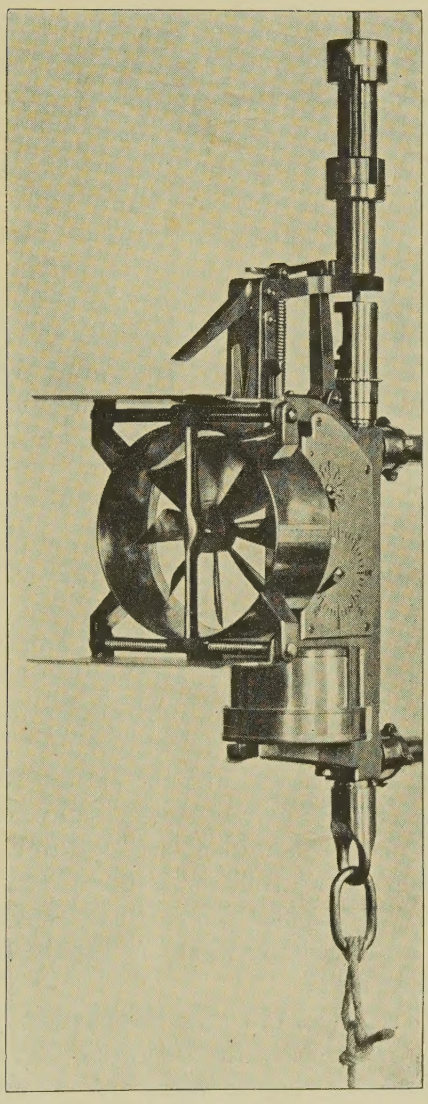

Fig. 3.

type of 1905 have been made with the object of attaining the following requirements, *viz.*:

1. More solid construction and more reliable functioning.

2. Easy reading of the instrument and saving of time in taking measurements.

3. Protection of the screw from drifting sea-weed and other clogging material till the very moment when measurement begins.

Figures 1—3 do not represent the very latest type, but the exterior differences are insignificant. Fig. 1, on the scale 1:10, is intended to show the general arrangement and the proportions of the current-meter. (The dimensions of the tail should be a small percentage greater than in the figure.) In Figs. 2 and 3 part of the instrument, before and after arrival of the messengers, is seen on a larger scale.

The main part of the instrument turns as usual in ball-bearings round its vertical axle. The upper end of the latter, or the "head" H, to which the sounding-line should be attached, is made after the simple pattern which was described in connection with the Repeating Current-Meter, although with an extra device for securing. The loop at the end of the sounding-line must not exceed 4.5 cm. in length, the knot included; it is intended, however, to get rid of this inconvenience by making the head considerably larger.

The direction of a weak current will easily be wrongly recorded, if the plane of symmetry of the current-meter is not exactly vertical, and if at the same time the tail and the front part of the instrument do not balance one another. I have endeavoured to avoid *both* causes of error. To secure as far as possible the vertical adjustment of the axle, the rope carrying the sounding-lead is not attached directly to the eyelet but to an extra link below it (Fig. 3). Furthermore the instrument (with its axle horizontal) is equilibrated in water.

The tail is made, in essentials, after the pattern introduced by MERZ (in his weak-current type of current-meter), and consists of a celluloid-painted aluminium plate, 2 mm. thick, attached to the main part of the instrument by means of two stout brass tubes. The latter are screwed to the plate (N.B. left-handed screws!) and afterwards fixed to the main part of the instrument by means of right-handed unions, which are pulled tight with a key.

The screw, with 8 blades of elastic sheet-bronze, 0.25 mm. thick, is of the same light pattern as in the Repeating Current-Meter. It runs inside a strong protecting ring, to which the two front shutters F are hinged. By pushing the catch P, the upper end of the bar, which carries the front bearing (Fig. 3), is set free and can be pulled forward for the purpose of inserting or taking out the screw. In doing this, care should be taken not to injure its Tantalium points; and the screw should never be left in the instrument after work is finished. This is worth emphasizing, since the writer has repeatedly witnessed the rough treatment to which various kinds of current-meters have been exposed, even being transported with the screw resting in its bearings!

Comparatively slow-running screws, *i.e.* with a high pitch, have been

found to give the most accurate results. Each screw has been calibrated by towing the current-meter (at velocities between 2 and 80 centimetres per sec.) in a channel of 20 metres length and 1 square metre cross-section. The screws were found to move regularly, even at the lowest velocities used; and the velocities v in cm./sec. could be calculated, with an error not exceeding half a unit, from a linear relationship

$$v = 0.5 + \mathrm{A}\, n,$$

n denoting the number of revolutions of the screw per minute. The coefficient A is about 0.6 and is only slightly different for the different screws. Each instrument is supplied with two screws, one as reserve.

Inside the protecting ring there is a stopper movable vertically. It is connected with the lever L, so that the screw is released or arrested according as the lever — or more properly its right arm, which receives the blows of the messengers — has a higher or a lower position. The lever is raised by the pressure of the spiral spring S. But it can be kept in its lower position; either as in Fig. 3 by a catch in the shape of a twin-spring T, or, as in Fig. 2, by its left arm resting at A against the closed upper shutter, which is in its turn locked by the lever. The instrument should be lowered into the water in the latter state with the shutters closed; furthermore the double spring should be pressed to the right, *i.e.* towards the sounding-line, in which position it is then kept by the ratchet C and misses catching the lever.

When hit by the first messenger the lever lets go its hold at A, with the result that the shutters fly open by the force of strong spiral springs, and the lever immediately takes its upper position. Then the ratchet lets go the twin-spring, which now resumes its natural position to the left and catches the lever once more when the latter is pressed down by the second messenger. In this way the screw is set free by the first messenger and is once more arrested on the arrival of the second one. Since the connection between the lever and the stopper is an indirect and elastic one, the impact of the messenger cannot be transmitted to the screw-blades.

The exact shape and dimensions of the messengers are of no essential consequence. I have used M. KNUDSEN's very convenient type, which can be manipulated with one hand, reducing its weight, however, to only 250 g.

The dial mechanism for recording the number of revolutions of the screw is contained within the dial-box and consists of the worm-wheel and of two cog-wheels, all of them silvered. The worm-wheel and the last cog-wheel carry hands which make one revolution for each 100 and

4000 revolutions of the screw respectively. The hands are adjustable and should be set at zero (= 4000) at the beginning of the work, but they should not be readjusted after each single measurement. The numbers on the dial are in reverse order so as to give *decreasing* readings, which is obviously the most convenient arrangement, when the differences are to be taken.

In the first instruments of the present type the wheels ran in ivory

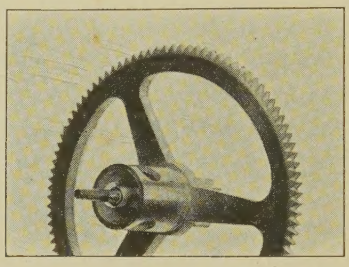

Fig. 4.

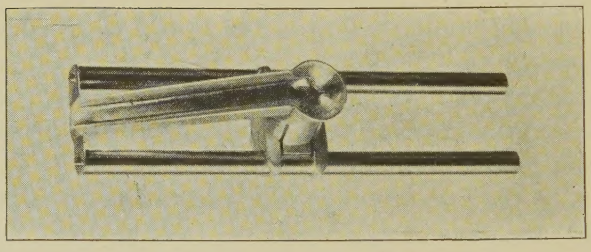

Fig. 5.

bearings, which, however, were soon replaced by stainless metal bearings, since the ivory is hygroscopic and swells in water.

The MERZ current-meter has the advantage that the worm-wheel and the wormed shaft of the screw are always visible for inspection, but at the same time they are, together with the whole gear mechanism, unprotected from drifting matter. Upon mature consideration I have preferred to have them carefully enclosed in the dial-box, which, for the purpose of inspection, can be opened wide from the back.

The arrangement for dropping balls into the compass-box is made on the same principle as is described in Publ. de Circonst. No. 34, p. 41, Copenhague 1906. An approximately vertical, tin-plated brass tube serves as a magazine for the balls. Its bottom is formed by a drum-wheel, attached to the axle of the worm-wheel. The drum-wheel has along its circumference three pits, each of which, when passing the magazine,

carries away the lowest ball and, after half a revolution of the wheel, drops it through a guide tube down into the compass-box. Originally these pits were cut out in the solid drum in the form of hemispherical cups. It has sometimes happened, however, that a ball has stuck to one of the cups, possibly owing to some small air-bubble in the latter, and in such cases the instrument is easily put out of order. To remove as far as possible this inconvenience the solid drum is now replaced by a hollow cylinder (of non-tarnishing "Monel Metal") with three circular holes in it, as seen in Fig. 4. A ball, falling down into one of the pits, stops against the axle itself, and there are two single points of contact only; and, further, there is no chance for an air-buble to stick in the

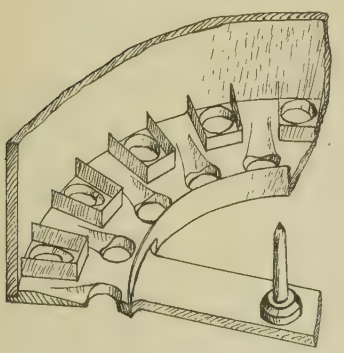

Fig. 6.

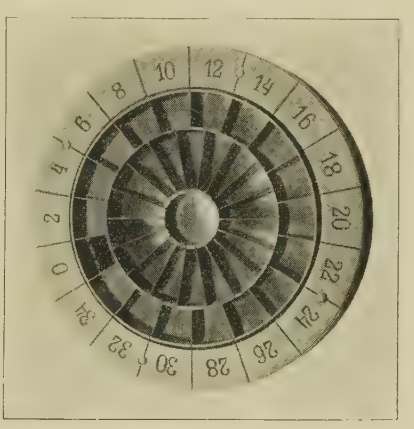

Fig. 7.

perforated cylinder. It is recommended that silvered bronze balls are used.

The magazine can be automatically loaded by means of a refiller after the pattern introduced by Merz.

The compass-needle, Fig. 5, is made with exchangeable magnetized rods after nearly the same pattern as has been previously used in the Repeating Current-Meter. The rods are now made of unplated, polished stainless steel (Fried. Krupp V 3 M) and are kept in position only by the friction of a spring.

The compass-box B, of which Fig. 6 gives an inside view, is in all essential details copied from the Repeating Current-Meter; and so is the receptacle R, though it corresponds only to the "front box" of the larger instrument. The lower part of the compass-box is divided by 36 radial partitions, and between them, in the bottom, are 36 holes

each opening into one compartment of the receptacle. These compartments therefore, and not the compass-box itself, finally receive the balls indicating the directions of the current. They are painted inside with white and red celluloid lake.

When the instrument has been hauled up after a measurement, one should close the shutters, remove the messengers and pull the twin-spring to the right. Then read the dial, pull out the receptacle and put it aside, insert another one (its red compartment should point forwards against the current) and, if necessary, load the magazine with balls; whereupon the instrument can immediately be sent down to take another measurement. Meanwhile there is convenient time to record the directions from the last measurement.

For this purpose the receptacle should be placed in the graduated circular frame (see Fig. 7), so that the red compartment has number zero. (The receptacle fits the frame, as well as the current-meter, in the correct position only). The compartments in the outer circle have then the even numbers 0—34, read on the frame, and the compartments in the inner circle the intervening odd numbers 1—35. A ball in compartment 0 indicates a current running N, and similarly the compartments 1, 2,.....35 correspond to the directions N 10° W., N. 20° W., ...N. 10° E.

All parts, for which no other covering has been mentioned, are nickel-plated. The length and height of the instrument, when ready for use, are 70 and 36 cm. respectively, and it weighs nearly 5 kg. without messengers. It is packed in a case of external dimensions 40 × 25 × 21 cm. and 12 kg. gross weight. It is made by J. & C. Lindelöf in Lund and can be obtained through the present writer.

On the Classification of Tides.

By

H. A. Marmer.

U. S. Coast and Geodetic Survey, Washington.

As an oceanographic feature the tide is a phenomenon of world-wide occurrence. Even in ancient times it was recognized that the rise and fall of the tide was in some way intimately connected with the movements of sun and moon, although the agency by means of which the heavenly bodies exerted their influence on the waters of the sea was not understood. However, with the formulation of the law of gravitation by NEWTON in the latter decades of the Seventeenth Century, the tide received a rational explanation, for NEWTON showed that it was a necessary consequence of gravitational attraction.

Now it can be shown that the tide-producing forces of sun and moon are distributed over the entire earth in a regular manner varying only with latitude[1]). The tide is, therefore, frequently assumed to constitute a relatively simple phenomenon which manifests itself in much the same way throughout the world. It is as such a simple phenomenon, for example, that the tide is presented in most text books on physical geography or astronomy.

Another cause, too, that has been potent in the oversimplification of the tide arises from the fact that the rise and fall of the tide on the shores washed by the Atlantic Ocean is of a relatively simple character. And since these tides were the ones which the earliest investigators had at hand for study, it was but natural that their simple character should be taken as typical.

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[1]) R. A. HARRIS; Manual of Tides, Part IVa; Outlines of Tidal Theory. U. S. Coast and Geodetic Survey Report, for the year 1900, Washington, 1900, Appendix 7, pp. 547—548.

The Variety of Tides.

With the growth of geographic knowledge and with the need of detailed information relative to tides in connection with various activities of modern life, there has come a better knowledge of the tides the world over. And instead of a simple phenomenon we find the tides presenting a bewildering variety of the most diverse features. Quite apart from differences in time and in range of tide, which may be considered as

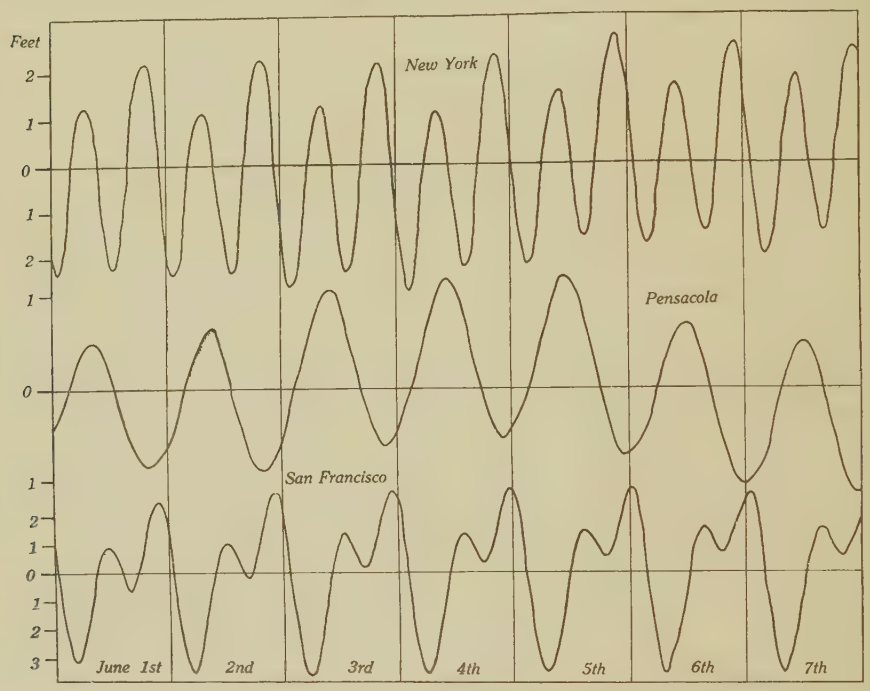

Fig. 1.

differences merely of degree rather than of kind, it is found that the tides at different places vary strikingly in the character of the rise and fall.

Take for example the record of the rise and fall of the tide for the first week of June, 1928, at New York, Pensacola, and San Francisco, shown in Figure 1. While the tide at each of these places varies throughout a month in response to changes in the position of the moon relative to earth and sun, the curves shown in Figure 1 may be taken as typical of the tidal rise and fall at these places. In New York Harbor it is seen that each day there are two high and two low waters, so that each rise and each fall of the tide occupies approximately 6 hours. Furthermore, it should be noted that morning and afternoon tides differ but little

either in extent or in duration of rise and fall. Parenthetically it is to be observed that a tidal day, like the lunar day, has a length averaging 24 hours and 50 minutes.

Now compare the tide at Pensacola, shown in the middle diagram, with that at New York. Here there is but one high and one low water a day, so that the rise of each tide as well as the fall occupies a period of about 12 hours against a like period of 6 hours at New York. And now glancing at the lowest curve, representing the rise and fall of the

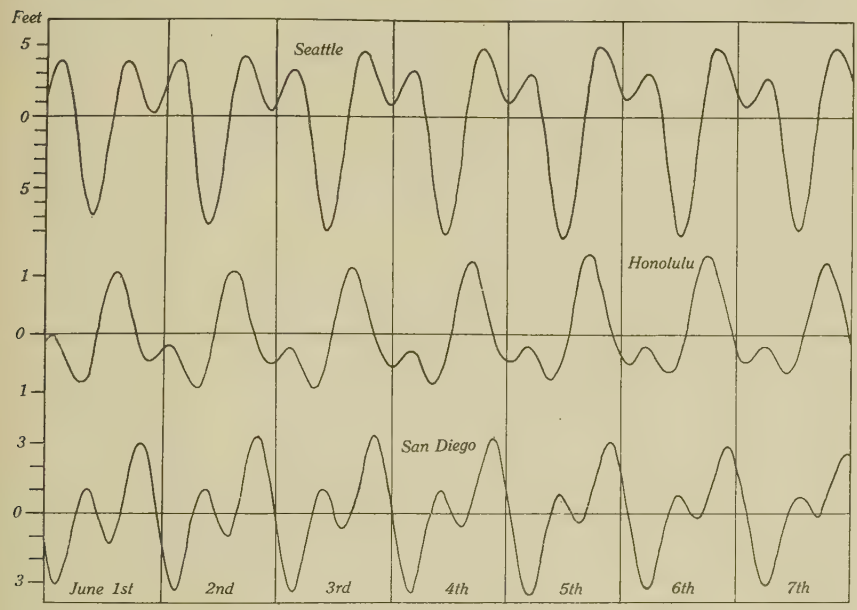

Fig. 2.

tide at San Francisco, we find a still different condition of affairs. Two high waters and two low waters occur here each day, but with striking differences between morning and afternoon tides. For the week shown, morning low waters are decidedly lower than the afternoon low waters. Furthermore, the morning rise occupies a considerably longer period than the afternoon rise — $7^{3}/_{4}$ hours against $5^{3}/_{4}$ hours for the week shown in Figure 1 — while the morning fall exhibits a corresponding difference from the afternoon fall.

The horizontal line associated with each of the tide curves represents the plane of sea level. And it is of interest to note that, whereas at New York each low water fell below this plane, at San Francisco the higher low waters fell below sea level only the first two days of the week shown,

while the last five days this low water was above sea level. This means, in other words, that at San Francisco the water is frequently above sea level continuously for more than half a day, a fact of importance in navigating channels of little depth.

It must be emphasized that the differences in the characteristics of the tide at the three places shown in Figure 1 are in no way due to disturbing effects of wind and weather. Heavy winds and wide variations in barometric pressure bring about very considerable disturbance in the regularity of the tidal rise and fall; but the first week in June, 1928, was chosen precisely because of freedom from such disturbing effects. The features found to distinguish the tides at the three places are characteristic tidal features for each of these three places.

Even a cursory examination of the characteristics of the tide at different places reveals the fact that these characteristics vary widely, and that the examples discussed above do not exhaust the different varieties of tides. In Figure 2 are shown the tide curves for Seattle, Honolulu, and San Diego for the same seven days of June, 1928, as in Figure 1. A glance is sufficient to show that the tide at each of these places differs from that of the others as well as from the tides at the three places represented in Figure 1.

At Seattle it is seen that two high waters and two low waters occur each day, as at New York and at San Francisco. The character of the tide at Seattle, however, differs from that at New York in that morning and afternoon tides are quite different. It is different also from the tide at San Francisco, for while at the latter place differences between morning and afternoon tides are exhibited by both high and low water, at Seattle these differences are exhibited almost wholly in the low waters. For the week represented, the tide at Seattle had a range averaging almost exactly 8 feet. During this period the difference between the two high waters of a day averaged but little more than a foot, with an extreme difference of a little over 2 feet. The difference between the two low waters of each day, however, averaged $8^{3}/_{4}$ feet, with a maximum difference of $9^{1}/_{2}$ feet. In other words, the difference between the two low waters of each day at Seattle for this period was greater than the average difference between the high and low waters. It is seen too, that during this period the higher low waters did not once fall below the plane of sea level.

At Honolulu, as the middle diagram of Figure 2 shows, tidal conditions are the exact reverse of those at Seattle, for at Honolulu the difference between morning and afternoon tides is exhibited almost wholly by the high waters. For the week represented the lower high

waters of each day did not once attain the height of the plane of sea level.

Examining now the tide curve for San Diego it is seen that tidal conditions here are midway between those at Seattle and at Honolulu. At San Diego the difference between morning and afternoon tides is divided almost exactly between the high waters and the low waters. This tide resembles somewhat the tide at San Francisco which is represented by the lower diagram of Figure 1. At the latter place, however, the difference between the low waters of a day is greater than between

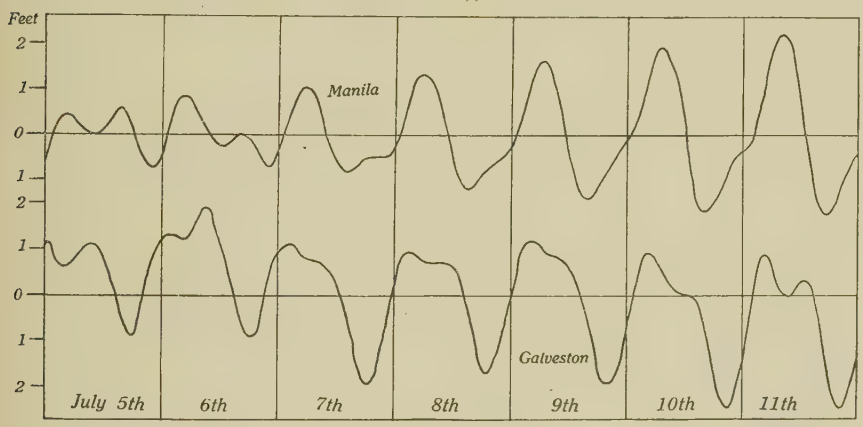

Fig. 3.

the high waters, while at San Diego it is featured in almost equal degree by both high and low waters.

As a matter of fact, the tide at any given place has certain characteristics of time, range or character of rise and fall which distinguish it from the tides at other places. What we are here concerned with, however, is with typical forms of the rise and fall of the tide and not with secondary features. The characteristics of the tides illustrated by Figures 1 and 2 exemplify six different typical forms of the tide to which the tides at many places approximate more or less closely. In addition to these six varieties of tide, three other varieties remain to be considered. Two of these are illustrated in Figure 3 by the tides at Manila and at Galveston for the seven days beginning July 5, 1919.

During the first two days represented in Figure 3, two high and two low waters occurred at Manila, while during the last four days but one high and one low water occurred. The tide on the 7th, which separates these two different groups of tides, is seen to be characterized by a long stand of the tide between the hours of 6^{00} p.m. and 11^{00} p.m.,

when the lower high water merged with the higher low water. This feature, which arises from the merging of a lower high water and a higher low water is known as the vanishing tide; and at Manila, it should be noted, the vanishing tide occurs below the plane of sea level.

At Galveston, there is a somewhat similar condition of tidal affairs. For the first two days represented there are two high and two low waters during each day. This is followed by two days featuring the vanishing tide, after which follow two days when but one low and one high water occur during each day. This in turn is followed by a day of two high and two low waters. At Galveston, however, the vanishing tide takes place above sea level.

A third variety of tide that exhibits somewhat similar features is one in which the vanishing tide takes place close to the plane of sea level. No observations, however, are at hand to illustrate this variety.

Now such striking differences in the tides as exemplified in Figures 1, 2 and 3, are most disturbing to any simple formulation of the connection between moon and tide. In the Pacific Ocean, for instance, we can find examples of each of the varieties of tides illustrated by the tide curves of the preceding Figures. With such great diversity in the tide of a single ocean, it is scarcely to be wondered at that from time to time, so-called "new theories" of the tide are proposed which do away with the sun and moon as the tide-producing bodies. In this respect the genetic classification of tides is extremely helpful; for not only does it provide for a simple classification into three types, but at the same time furnishes an illuminating insight into the relation between moon and tide.

The Classification of Tides.

In view of the fact that tides differ in time, range, and characteristics of rise and fall, they may be classified in various ways, depending on the features chosen as criteria. For example, tides may be classified in accordance with range or in accordance with time as related to the moon's meridian passage. But since time and range are in a sense isolated features unrelated to the genesis of the tide, such classifications give no insight into the complex manifestations of the tide, and thus have little to commend them. Moreover, time and range of tide vary considerably even within restricted areas, depending on local hydrographic conditions.

Tides may also be classified in accordance with their predominant response to the moon's tide-producing forces. Thus tides may be grouped into those which respond primarily to changes in the moon's phase,

those which respond principally to changes in the moon's parallax or distance, and those which respond principally to changes in the moon's declination. Such a classification is more informative than one based on range or time of tide, but is not of as simple and fundamental a character as that based on the form of the tide curve.

The form of the tide curve is a fundamental feature which determines the variations in time and in height of rise and fall of the tide in response to changes in the positions of sun and moon relative to the earth. In other words, the form of the tide curve may be related directly to the tide-producing forces, so that a classification of tides in accordance with form of tide curve constitutes a genetic classification.

The nine varieties of tides discussed in the preceding section, and other sub-varieties, may be classified into three types of tide in accordance with form of tide curve. These three types are semidaily tides, daily tides and mixed tides. Instead of semidaily and daily, the terms semi-diurnal and diurnal are frequently used.

In connection with the classification of tides into types, the difference between morning and afternoon tides is an important criterion. It will therefore be of advantage to substitute for the cumbersome phrase "difference between morning and afternoon tides" the much shorter technical term, which is "diurnal inequality" or, for short, inequality. It may be noted that the inequality may be featured either in the times or the heights of the tide, and either in the high waters or low waters.

Characteristics of the Three Types of Tides.

As is implied in the name, the semidaily tide is one that has a period of half a day; that is, there are two high and two low waters in a tidal day. The further distinguishing characteristic of this type of tide is the presence of but little diurnal inequality. This means that in this type of tide the two high waters as well as the two low waters of a day differ but little either in duration or extent of rise and fall.

The tide curve for New York, illustrated by the upper diagram of Figure 1, may be taken as exemplifying the semidaily type of tide. On the Atlantic coast of the United States, and on the shores of the Atlantic Ocean in general, the semidaily is the prevailing type of tide.

The daily type of tide is characterized by the occurrence of but one high water and one low water in a day. In a sense, therefore, this is the simplest type of tide. It is, however, not very widely distributed. Certain regions in the Gulf of Mexico, in Alaska, in the Philippine Islands, on the coast of China and in other scattered localities exhaust the list of places exhibiting this type of tide. The middle diagram of Figure 1,

which represents the tide at Pensacola, Florida, illustrates this type of tide.

The mixed type of tide is characterized by the occurrence of two high and two low waters in a day, with considerable inequality between the morning and afternoon tides. As exemplified by the tide curves of Figure 2, the inequality may be featured in various ways; principally in the low waters, principally in the high waters, or in approximately equal degree by both high and low water.

The daily type of tide can be clearly distinguished from both the semidaily and mixed types, since the former has but one high and one low water a day, while the latter have two high and two low waters. But as between the semidaily and mixed types of tide no sharp line of demarcation is possible, for the distinction between these two types hinges on the amount of inequality present, the semidaily type exhibiting little inequality and the mixed type exhibiting considerable inequality. It is to be remembered, too, that in both the semidaily and mixed types of tide the inequality varies throughout a fortnight in accordance with the changing declination of the moon. In both the inequality is greatest at the times of the moon's maximum semimonthly north or south declination, and least at the times of the moon's least declination, that is, when the moon is on or near the equator. Hence, during the fortnight, when the moon attains its greatest declination tides of the semidaily type will exhibit relatively considerable inequality, and the tide curve will resemble that of the mixed type. Conversely, each fortnight when the moon is on or close to the equator, the diurnal inequality is least, and the tides of the mixed type resemble those of the semidaily.

In view of the changing inequality in the tide in response to the change in the moon's declination, it is clear that it is the prevailing characteristics of the tide at any given place throughout a fortnight that determine the type of tide at that place. If for the greater part of this period the tide exhibits little inequality, it is classed with the semidaily type; if for the greater part of a fortnight the tide exhibits considerable inequality, it is classed with the mixed type. For technical purposes certain ratios between the constituent tides are made use of in distinguishing between these two types of tide. But before taking this up it will be necessary to consider the origin of the mixed type of tide.

The Mixed Type of Tide.

The mixed type of tide comprises a variety of different forms, as illustrated in Figures 2 and 3. This type stands between the daily and

semidaily types. In fact, it can be easily shown that the mixed type of tide is indeed a mixture or combination of the daily and semidaily types and that the different forms of the mixed tide result from different combinations of the daily and semidaily constituent tides. The following considerations make this clear.

Suppose that within a given region of the sea the tide-producing forces give rise to both a semidaily and a daily tide of equal range. The

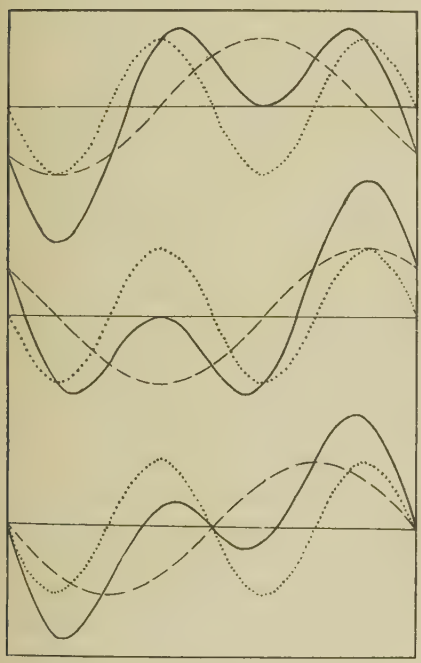

Fig. 4.

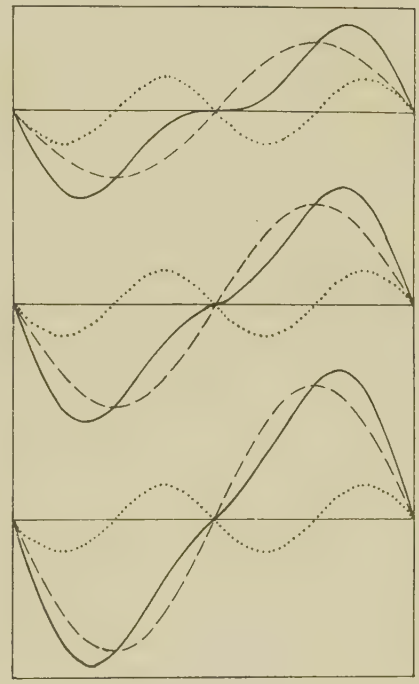

Fig. 5.

rise and fall of each of these constituent tides for a day may be represented as in Figure 4, the semidaily tide by the dotted curve and the daily tide by the dashed curve. Clearly then, the height of the resultant tide at any moment is the sum of the heights of the constituent tides at that moment. In Figure 4 the resultant tide is shown by the full-line curve.

The two constituent tides may combine in various ways as regards time. In Figure 4 three cases are considered. The upper diagram represents the tide resulting when the low waters of the two constituents occur at the same time. In that case it is seen that the resultant tide is of the mixed type with the inequality wholly in the low waters. This resembles

closely the tide at Seattle exemplified by the upper diagram of Figure 2.

If the times of the two constituent tides are such that the high water of the semidaily comes at the time of the low water of the daily, the condition of affairs will be represented in the middle diagram of Figure 4. The resultant tide is again of the mixed type, but now the inequality is featured wholly in the high waters. This tide, it may be noted, resembles closely the tide at Honolulu which is illustrated in the middle diagram of Figure 2.

Finally, if we take the two constituent tides to be at sea level at the same instant, as shown in the lower diagram of Figure 4, the resultant tide will still be of the mixed type. But now both high and low waters feature the diurnal inequality in equal degree, which case is exemplified by the tide at San Diego illustrated in the lower diagram of Figure 2.

The examples illustrated in Figure 4 represent the three type forms resulting from the combination of a daily and a semidaily tide of equal range. If these constituents are taken to combine with time relations differing from the three examples, the resulting tide will always be found to be a mixed tide with the inequality apportioned in different degree as between the high and low waters, but approximating more or less closely to one or other of the three forms represented in Figure 4.

The three examples of Figure 4, illustrating the combination of a daily and a semidaily tide, were limited to constituents having equal ranges. What happens if the ranges of the two constituents are different? In Figure 5 are shown the tides resulting under such conditions. For the upper diagram of this figure the daily has a range twice as large as the semidaily; in the middle diagram three times as large; and in the lower diagram four times as large. As in the previous example the semidaily is represented by the dotted curve, the daily by the dashed curve and the resultant tide by the full-line curve.

For the sake of illustration the times of the daily and semidaily constituents of Figure 5 were taken so that they are at sea level at the same instant. Under these conditions it is seen that when a daily tide combines with a semidaily tide having a range twice that of the semidaily, a vanishing tide occurs at sea level. And if the range of the daily is greater than twice that of the semidaily, only one high and one low water occurs in a day, as the two lower diagrams of Figure 5 show.

It should be noted that if in the case of the upper diagram of Figure 5 the two constituents are taken to combine with different time relations the result will be a mixed tide with the inequality in both high and low waters. But without going into greater detail relative to this phase

of the matter it may be said that further study would bring to light the following conclusions.

In the combination of a daily and a semidaily tide, if the range of the daily constituent is less than twice that of the semidaily, the resulting tide will be of the mixed type with two high and two low waters a day, the inequality depending on the time relations of the two constituents. If the range of the daily constituent is between two and four times as great as the semidaily, the resulting tide will exhibit either two high and two low waters a day, or only one high and one low water depending on the time relations between the two constituents. If the range of the daily constituent is more than four times that of the semidaily, only one high and one low water will occur in a day.

From the foregoing it appears that the type of tide depends on the relative magnitudes of the daily and semidaily constituents. By means of the harmonic analysis the different constituent tides present in the tide at any place may be derived. In accordance with the harmonic notation where the ratio of $(K_1 + O_1)$ to $(M_2 + S_2)$ is less than 0.25, the tide is of the semidaily type; where this ratio is between 0.25 and 1.25 the tide is of the mixed type; and where this ratio is greater than 1.25 the tide is of the daily type[1]). In this ratio K_1 and O_1 represent the principal daily constituent tides, and M_2 and S_2 represent the principal semidaily constituent tides.

Origin of the Different Types of Tide.

In the preceding discussion the different varieties of tides, with their seemingly unrelated characteristics, have been traced back to the combination of semidaily and daily constituent tides of different ranges and times. The question now arises, Why do the waters of the sea in different places respond differently to the same set of tide-producing forces?

In seeking an answer to this question it is necessary to draw upon considerations of a hydrodynamic nature. Briefly, it is to be noted that any body of water has a natural period of oscillation which depends on its length and depth. Furthermore, in responding to periodic forces that tend to disturb its equilibrium a body of water will respond best, or resonate, to that force the period of which most closely approximates to its natural period of oscillation.

The principal tide-producing forces of sun and moon are those having

[1]) See Otto Krümmel: Handbuch der Ozeanographie (2 vols. Stuttgart, 1907—1911). Vol. 2, p. 266.

periods of half a day and a day, respectively. As these tide-producing forces sweep over the earth they put into oscillation the waters of the various oceanic basins. But the response of any given oceanic basin to these forces depends on its natural period of oscillation, which period is determined by the length and depth of the basin. Those basins whose natural periods of oscillation approximate to half a day respond best to the semidaily tide-producing forces; hence the semidaily constituent of the tide will predominate and the tide in these basins will be of the semidaily type. Those bodies of water whose natural periods of oscillation approximate to a day will respond best to the daily tide-producing forces and thus give rise to daily tides. At the same time, those bodies of water, the natural periods of oscillation of which approximate to the daily forces as closely as the semidaily forces, will respond in approximately equal degree to both kinds of tide-producing forces and hence give rise to mixed tides.

It is to be noted further that both the semidaily and daily tide-producing forces vary in intensity from day to day throughout a fortnight, the daily being greatest when the moon is at its semimonthly maximum north or south declination and the semidaily being greatest when the moon's declination is least, or in other words, when it is on or near the equator. It is in this varying relation of the magnitudes of the daily and semidaily tide-producing forces throughout a fortnight that we find the explanation of tides which part of the time are mixed and part of the time are daily, exemplified by the tides at Manila and Galveston in Figure 3.

Advantages of the Genetic Classification of Tides.

The genetic classification of tides into the three types discussed above clearly gives an illuminating insight into the diverse characteristics manifested by the tides of the seven seas. Moreover the mere statement with regard to the type specifies concisely a number of characteristic features.

Thus, when it is stated that the tide in New York is of the semidaily type, it follows immediately that in this harbor two high and two low waters occur each day, that there are no large variations in consecutive ranges, and that the variation in range from day to day will depend primarily on the variation in the phase and parallax of the moon. It follows, too, that the durations of rise and of fall will at all times be approximately six hours, except as affected by wind and weather. Similarly, by classing the tide at Pensacola as the daily, it becomes known immediately, not only that here but one high and one low water

occurs each day and that the durations of rise and fall are each 12 hours, but that the greatest rise and fall comes at the times of the moon's semimonthly declination rather than at full and new moon.

Turning now to the mixed type of tide, the tide at Seattle would be specified as being of the mixed type with the inequality principally in the low waters. This makes known at once that while there are two high and two low waters a day at this port, wide variations in consecutive ranges occur, that the two high waters of a day do not differ much but that the two low waters differ considerably. Furthermore, that speci fication also implies that the differences between the low waters are greatest at the times of the moon's semimonthly maximum declination and least when the moon is close to the equator.

The tide at Honolulu would be specified as of the mixed type with the inequality principally in the high waters, while the tide at San Diego would be specified as being of the mixed type with the inequality in both high and low waters. For Galveston the specification would be a mixed tide, which frequently becomes diurnal, and with the inequality principally in the low water. For Manila it would be a mixed tide which frequently becomes diurnal, and with the inequality principally in the high waters. These concise specifications would immediately make known the larger features of the tide at each of these places.

The classification of the tide into the three different genetic types has further advantages in various activities that involve tides. For example, in the construction of coast and harbor charts the choice of the most suitable datum to which the soundings are to be referred is an important matter[1]). For tides of the semidaily type the most suitable datum is that of mean low water or spring low water, depending on the range; while for the mixed and daily types of tide the datum of lower low water is generally the most suitable. The specification of a tide by its type thus immediately determines the most suitable datum plane to be used.

Likewise, in connection with the delimitation of lands fronting the sea the classification of tides by type is of advantage. For the "high water line" which is used for this purpose is clearly different for tides of the mixed and semidaily types. For the latter this refers to the plane of mean high water, while for the former the plane of higher high water is the more satisfactory.

[1]) H. A. Marmer; Chart Datums. U. S. Coast and Geodetic Survey Special Publication No. 170. Washington, 1930.

Summary.

This paper describes the genetic classification of tides into three types. The different varieties of tides are shown to be different forms of these three types. It is further shown that these three types arise from the presence of two elementary constituent tides, which are traced back to the tide-producing forces. The seeming variation in type at different places is shown to result from periodic variations in these elementary tide constituents. Finally, the advantages of the classification of tides into the three genetic types is discussed.

The Consumption of Nutrient Salts in the Barents Sea.

By

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The first step in the study of the sea is the investigation of the general conditions, the second is the study of the annual variations with the seasons and, finally, the fluctuations from year to year. It is the latter which are of the greatest interest from the point of view of the fisheries, which themselves fluctuate from year to year.

The importance which is nowadays attributed to the nutrient salts as a factor potent in its effect upon marine life is well known. A considerable amount of data is already collected concerning the phosphates and nitrates in the Barents Sea, their concentration and the general picture of their distribution (the cruises of the vessels of the Oceanographic Institute, Moscow; expeditions of the icebreaker "Ssedov"; the work of the Norwegians in the coastal areas of the western Barents Sea). Some information has already been obtained concerning the seasonal changes in the nutrient salts (KREPS and VERJBINSKAYA, 1930). The fluctuations in phosphates and nitrates from year to year in the Barents Sea remain quite unknown.

The present paper deals with some new, more detailed data concerning the seasonal variations in the concentration of the nutrient salts in the central part of the Barents Sea, and with some comparative data concerning the fluctuations in the nutrient salts during the years 1929 and 1930.

The observations reported below were made during periodical cruises by the vessels of the Oceanographic Institute along the meridian 33°30′ E.

(Kola meridian) from the Murman shore up to the ice margin[1]). The present data are the results of 7 cruises — in March—April, June, August, September and November 1930 and in January and March 1931. The cruise in August 1930 was made on board the steamer "Persey", all the other cruises on board the motor-cutter "Nikolai Knipovitch".

The determination of phosphates, nitrates and pH was made in the same way as described in our previous paper (1930). The data dealt with here are given in tables and diagrams. The phosphate data represent mg. of P_2O_5 per cubic metre, the nitrate data mg. of nitrate + nitrite N_2 per m^3. Besides the distribution of phosphates, nitrates and pH, a picture of temperature distribution is also given, as it is necessary for a clear understanding of the peculiarities of the physical and chemical conditions of the sea area studied.

As is well known, a drift of Atlantic water flows round the North Cape into the Barents Sea. This drift of water, generally called the North Cape current, is divided into several branches; the southernmost, moving along the Murman coast, is known as the Murman current. The northern one, which crosses the Kola meridian at lat. 75°—76° N., is known as the Franz-Joseph branch.

The seasonal changes in nutrient salts.

These new data allow us to follow more closely the summer consumption of the nutrient salts. The annual cycle of phosphates and nitrates, connected with the vernal outburst of plant growth and the autumnal regeneration and upwelling of phosphates and nitrates, may be traced on the cruises from March to November.

The curves in Fig. 1 show the annual changes in phosphate content at the depth of 10 metres. As a typical area of Atlantic water the station at 71°30′ N. is chosen. Stations lat. 73°30′ N. and 75° N. are examples of Arctic stations. Inshore waters are represented by station lat. 70° N. As there was no cruise in May 1930, the results of the cruise in May 1929 are introduced in the curves.

The curves show that 1) In the Atlantic water the vernal depletion of phosphates is retarded as compared with the Arctic waters. 2) The re-establishment of the phosphate content in the upper strata is also in advance in the Arctic waters. 3) The rate of the replenishment of

[1]) Each section along the Kola-meridian was followed by a section along the meridian 38° E., but we shall confine ourselves to the results collected on the Kola meridian only.

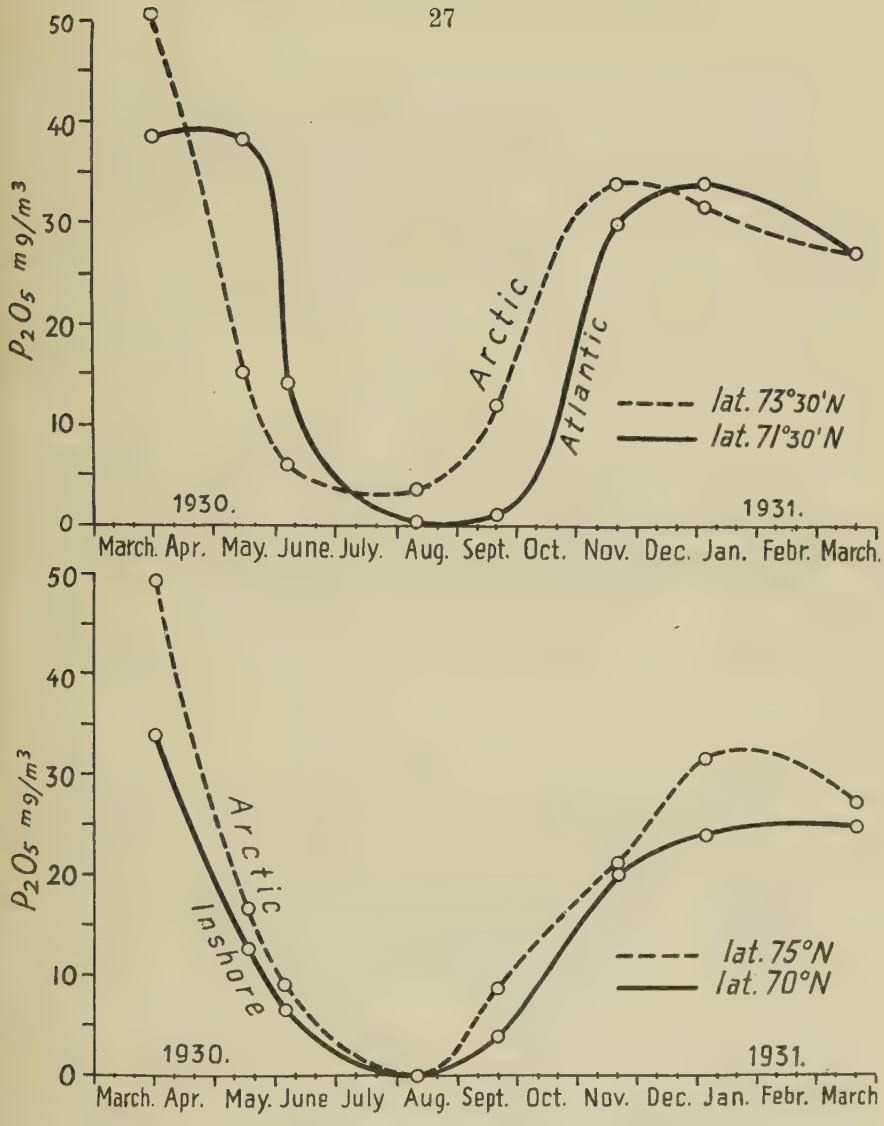

Fig. 1. Annual variation of phosphate content. Depth 10 metres. Upper curves = Arctic and Atlantic waters; lower curves = Arctic and inshore waters.

phosphates in the upper layers is maximal during October—November. 4) The growth of the phytoplankton brings about a complete depletion of phosphates and nitrates. During the vegetation period the vertical mixing is so insignificant as compared with the intense utilisation of phosphates and nitrates that the concentration of nutrient salts falls to zero.

The curve for the inshore waters is very similar to the curve for the Arctic waters.

The reason for this difference between waters of different origin remains at present unsettled.

The coastal and the Arctic waters are similar not only with respect to a simultaneous outburst of plankton growth, but also with respect to the composition of the phytoplankton. According to the information kindly supplied by B. M. Persidsky, the abundant phytoplankton of the Arctic and the coastal areas in May 1929 consisted mostly of the arctic *Phaeocystis puchetii* and the neritic *Thalassiosira nordenskioldi*, *Th. gravida* and *Chaetoceras debile*. The regions of the warmer Atlantic water, situated between the inshore water and the areas of the cold Arctic water, contained a very poor population of merely boreal oceanic species. The similarity in plankton compositon of the polar and the coastal waters was noted by many investigators (Brandt 1916—1920, Nansen, Gran 1931). Prof. Gran compares the influence of the ice to that of the shore, considering the Arctic water as a kind of "coastal" water, where the "coast" is represented by the polar ice. Opposed to the Arctic and to the coastal waters stands the oceanic Atlantic water.

The abundant and early vegetation of the "coastal" waters Gran is ready to explain by an influx of stimulating substances from the "coast". These substances are not the nutrient salts, for the inshore waters of the Barents Sea are the poorest in phosphates and nitrates. It is possible that a different composition of spores of the plankton algae in waters of different origin may to some extent be responsible for the observed difference.

The annual variations in the hydrographic conditions along the Kola meridian are shown by the diagrams of the sections (Figs. 2—8).

In March a mixing of all the layers takes place. No vertical layering can be detected. A uniform concentration of phosphates, nitrates and hydrogen ions occurs from top to bottom. The Arctic, the Atlantic and the inshore waters differ as to their relative richness in nutrient salts, the Arctic waters being the richest and the inshore waters the poorest.

In June (4—10) the diagrams of phosphate, nitrate and pH distribution are also very similar. They show a strong depletion in the upper layers, especially in the regions of the inshore waters (69°30′—70°) and of the Arctic waters (around lat. 73° and lat. 75°), the beginning of phytoplankton growth being here in advance, as compared to the regions of Atlantic water. The areas of the maximal consumption of phosphates and nitrates (lat. 76° -76°30′ N.) show also the greatest rise in pH. Here the phosphates are entirely used up, and only small traces of nitrates (2 –5 mg. NO_3/N_2 per cubic metre) are left; the pH becomes 8.35—8.36.

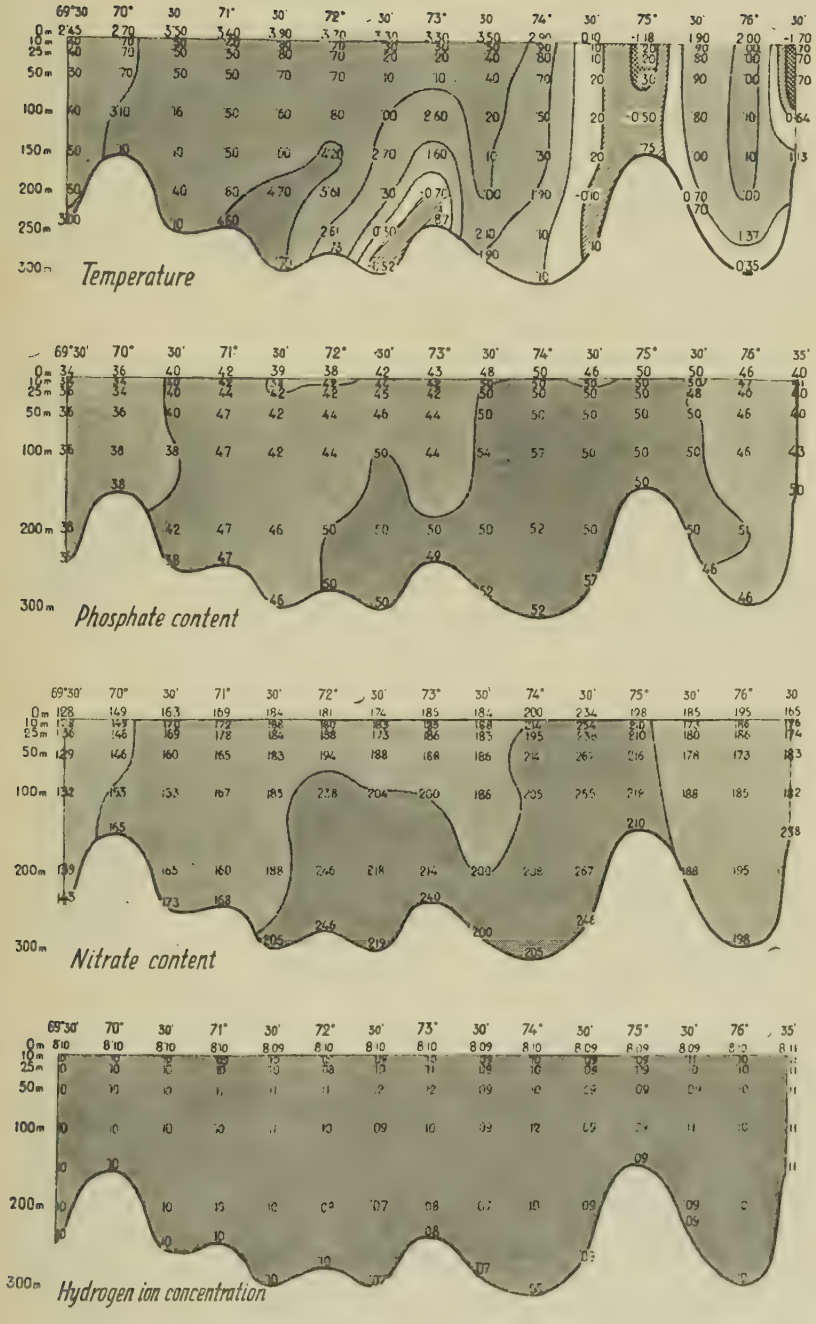

Fig. 2. Temperature, phosphate and nitrate content, and hydrogen-ion concentration along the Kola meridian, March 28—April 6, 1930.

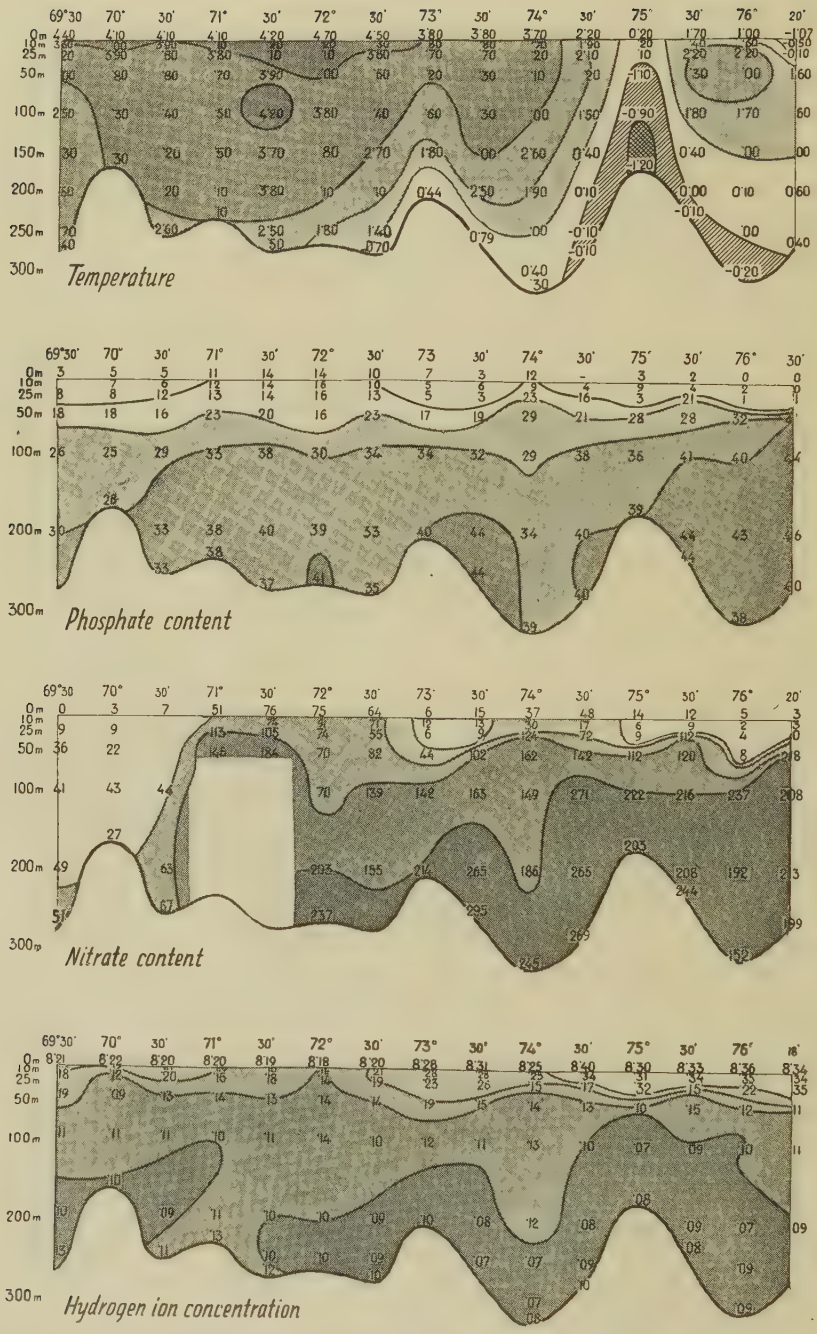

Fig. 3. Temperature, phosphate and nitrate content, and hydrogen-ion concentration along the Kola meridian, June 4—10. 1930.

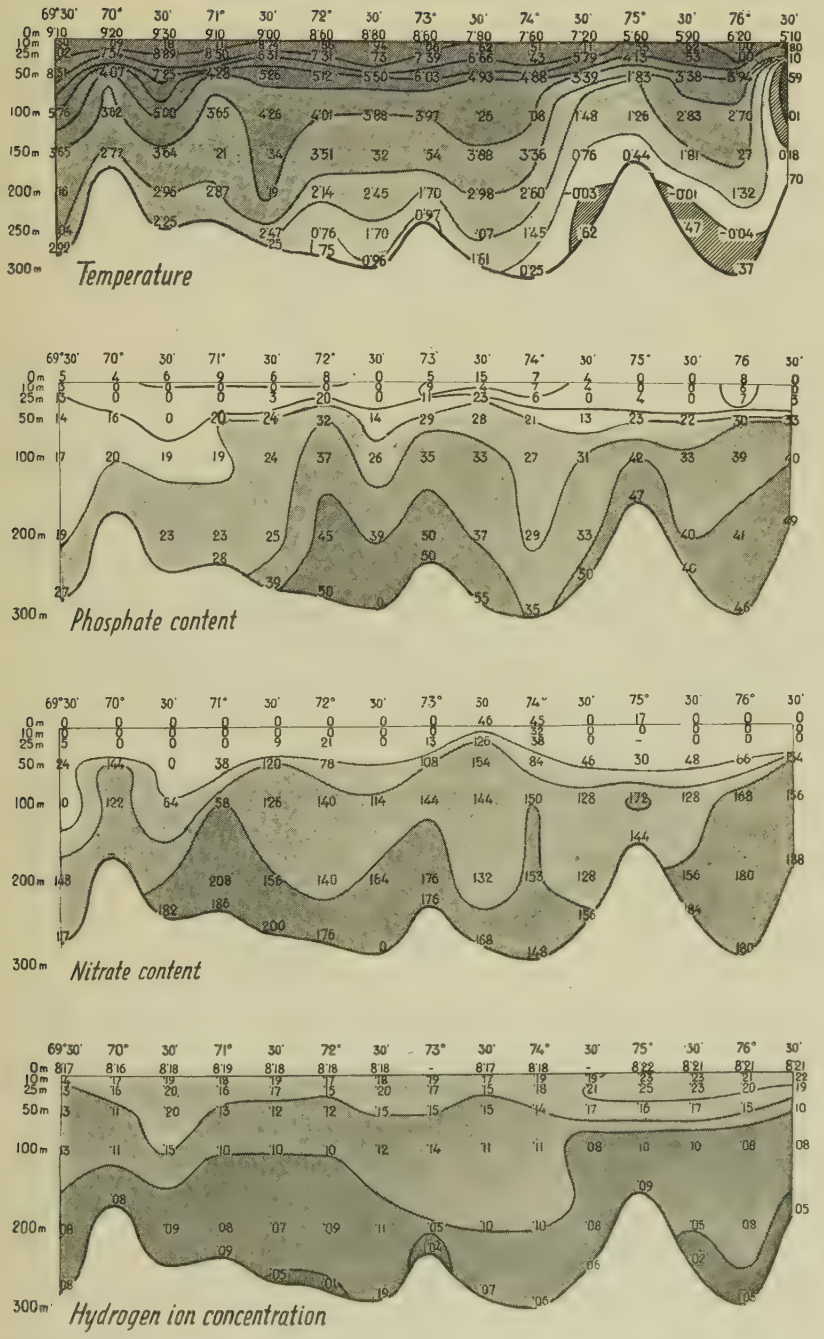

Fig. 4. Temperature, phosphate and nitrate content, and hydrogen-ion concentration along the Kola meridian, August 8—16, 1930.

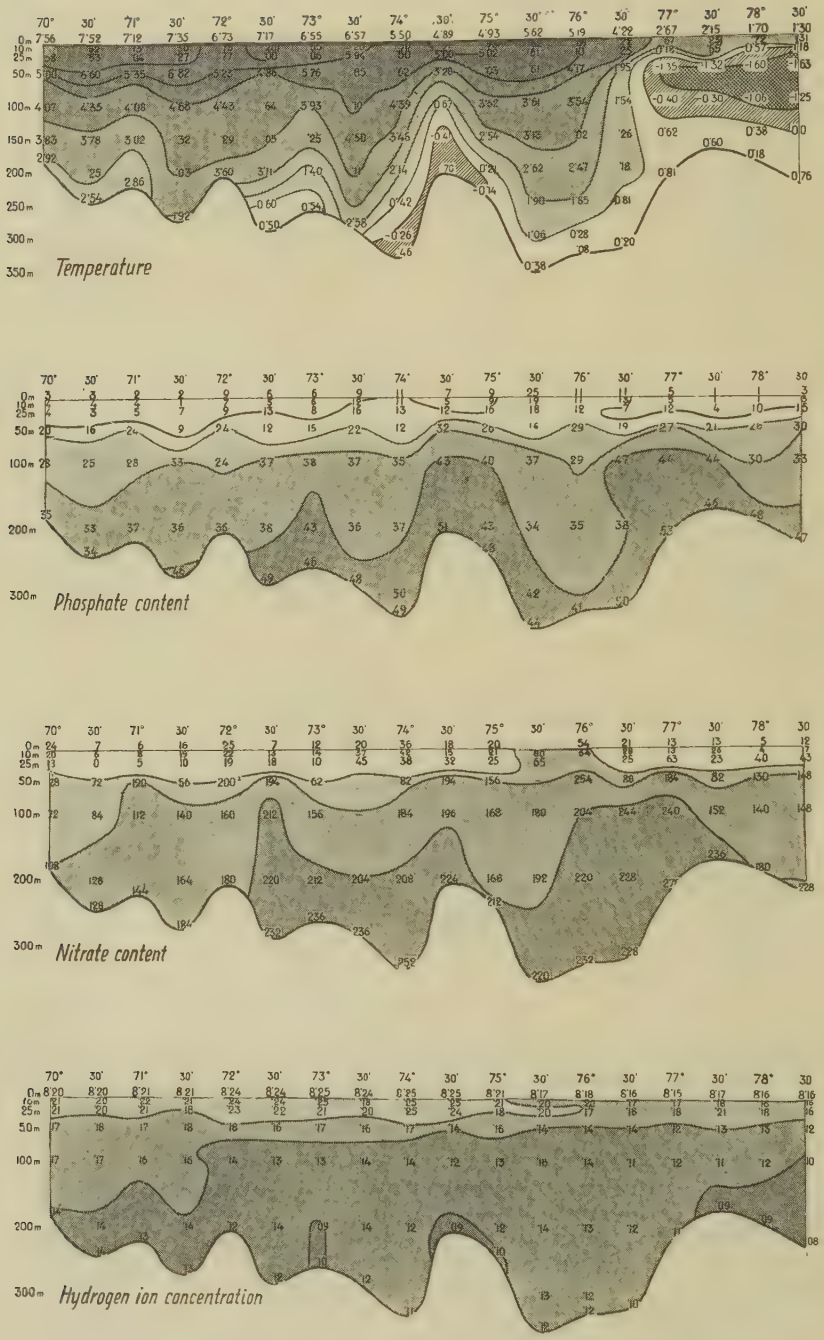

Fig. 5. Temperature, phosphate and nitrate content, and hydrogen-ion concentration along the Kola meridian, September 20—24, 1930.

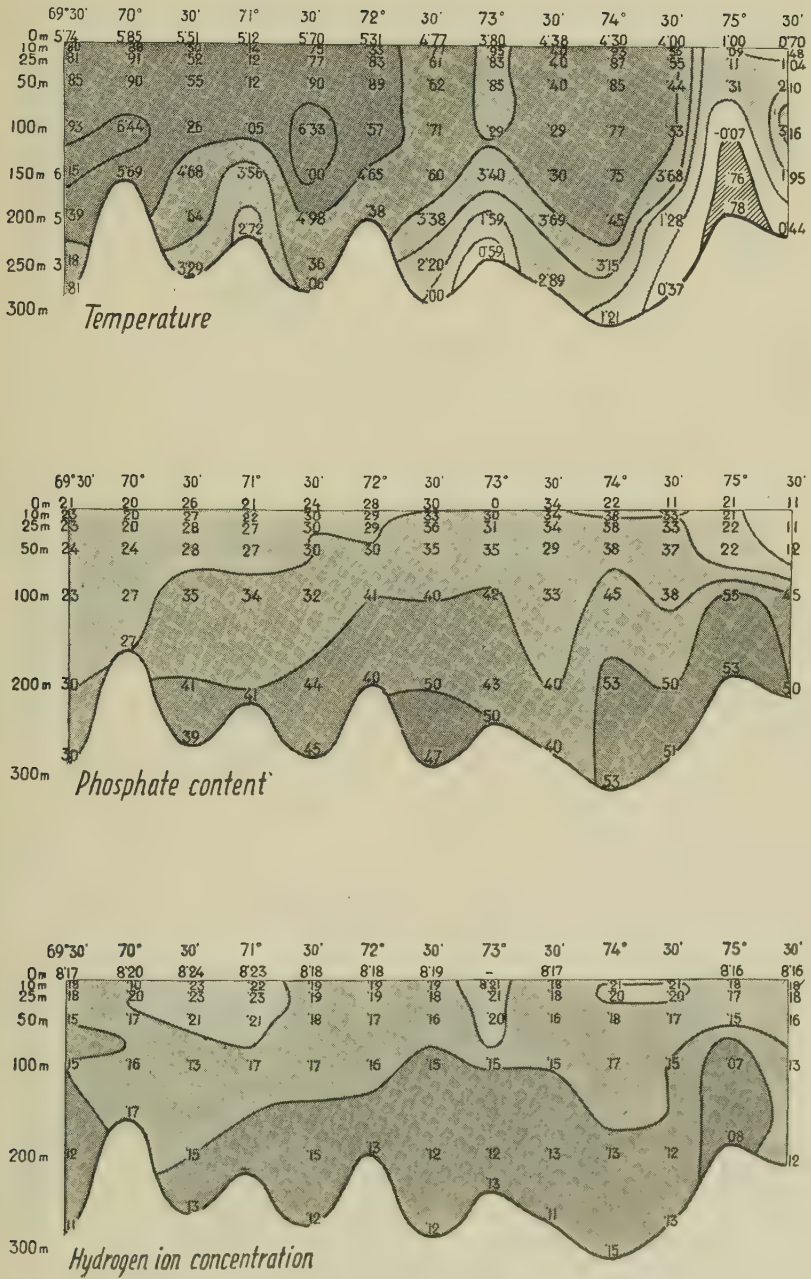

Fig. 6. Temperature, phosphate content and hydrogen-ion concentration along the Kola meridian, November 18—25, 1930.

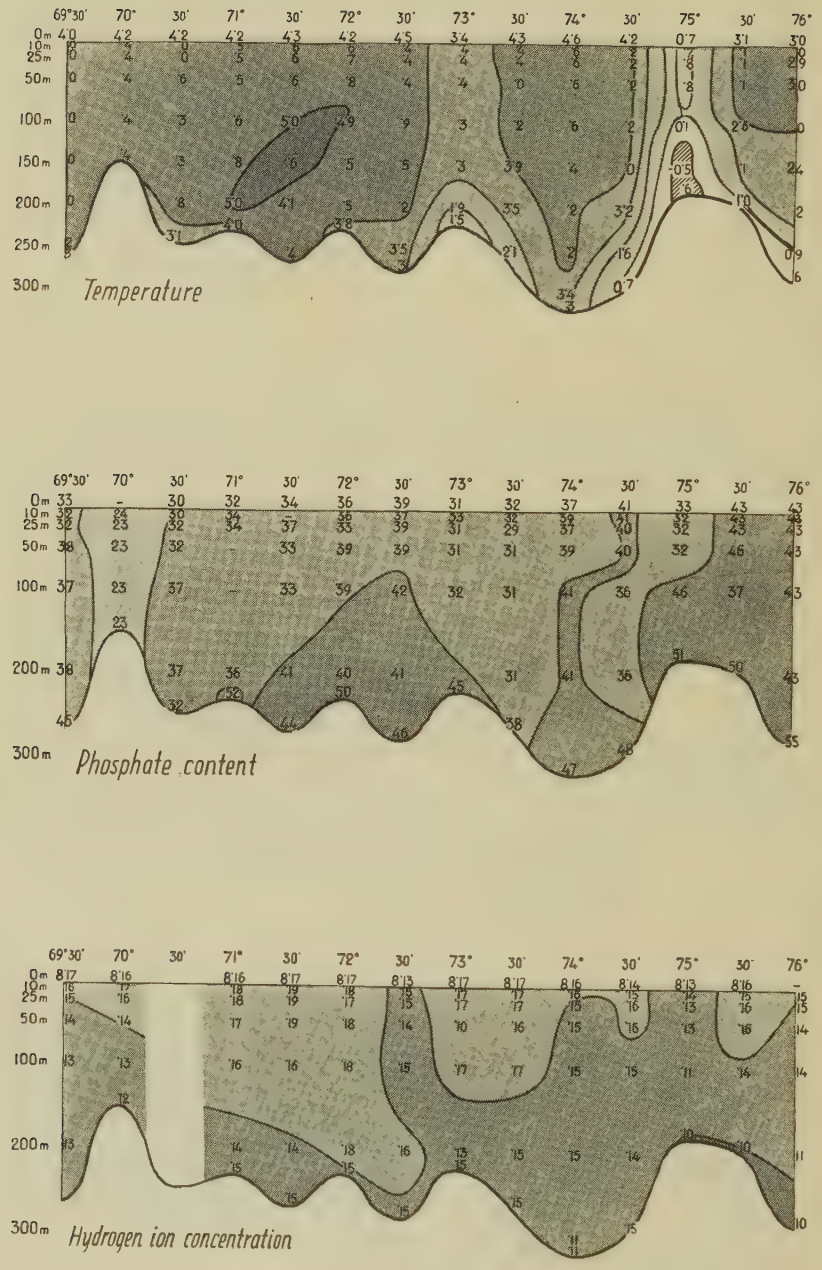

Fig. 7. Temperature, phosphate content and hydrogen-ion concentration along the Kola meridian, January 2—6, 1931.

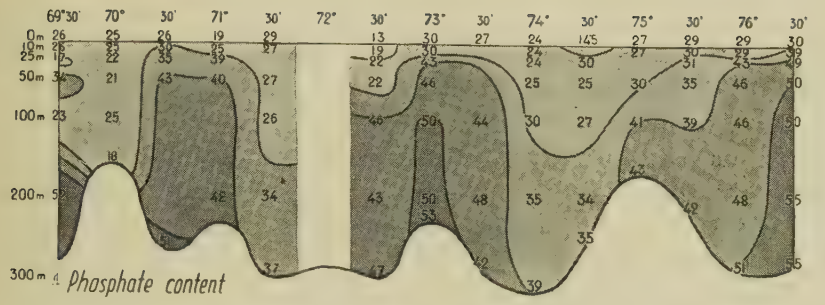

Fig. 8. Phosphate content along the Kola meridian, March, 19—24, 1931.

In August (8—16) the summer depletion of nutrient salts reaches its maximum. The phosphates and nitrates in the upper 25 metres are completely consumed almost everywhere along the meridian. Neither of these two salts is left in excess; neither alone plays the rôle of a factor limiting the phytoplankton production. Not always is such a parallelism observed. In many cases one of the nutrient salts may be completely used up, whereas the other remains in considerable concentrations (Gran (1930), Schreiber (1928), Atkins (1926)).

Many observers have mentioned the fact that the plankton algae find optimal conditions at a depth of some 10—25 metres, but not at the surface. The distribution of the phosphates in August gives a good illustration of this. Most of the authors are inclined to explain this phenomenon by a too strong action of light at the surface, noxious to the existence of plankton algae (Schreiber (1928), Marshall and Orr (1927), Gran and others).

The areas of the most intense consumption of phosphates in June show in August a considerable increase of the phosphate content in the upper layers. Presumably the re-establishment of the phosphates by local regeneration or by incursion of water richer in phosphates predominates at these places over the utilisation of phosphates. (The distribution of specific volumes at this time of the year makes rather improbable a somewhat intense vertical mixing of the water by convection currents.)

All the other stations of the section show a complete depletion of phosphates and nitrates in the 10—25 metres column.

The next cruise in September (20—24) brought to light a marked increase in nutrient salts in the upper layers. The utilisation of the nutrient salts is diminished and the increasing vertical mixing provides fresh supplies of phosphates and nitrates from below. Only the most northern stations remain quite depleted of phosphates and nitrates.

Some places are distinguished by an especially intense re-establishment of the phosphate content in the upper strata (lat. 74° N. and 75°30′—76° N). The temperature diagram shows that these stations correspond to the boundaries between the cold Arctic and the Atlantic waters. The same areas had been also in advance with respect to the re-establishment of the phosphate content in September of the previous year. It is very probable that death, sinking and decay of plankton organisms proceed at these places at a maximal rate.

The most alkaline reaction in the upper strata was observed in June, when the sea water was not yet totally stripped of the phosphates and nitrates and photosynthesis was proceeding with greatest intensity. In August the phosphate content was still lower, but the hydrogen-ion concentration had increased a little, especially at the places at which the most alkaline reaction was observed in June. This indicates a decrease in the photosynthetic activity. In September the whole section, with the exception of the northernmost stations (lat. 75°—76° N.), again shows an insignificant shift to the alkaline side, probably produced by a new secondary outburst of phytoplankton growth (personal communication by B. M. Persidski).

The November (18—25) section shows a marked change, which had taken place during the previous two months. The phytoplankton activity has ceased and an intense vertical mixing has set in. The concentration of phosphates, nitrates and hydrogen ions has increased. At this time all the conditions are determined by the vertical mixing.

In January 1931 (2—6) a fairly complete mixing of the waters had taken place. The phosphates and pH show a completely uniform distribution from top to bottom.

In March 1931 (19—24) the beginning of the diminution of nutrient salts is already perceptible at some points of the section. Evidently the vernal multiplication of plankton algae began in the spring of 1931 much earlier than in the spring of 1930.

Comparison of the years 1929—30 and 1930—31.

The most important event in the régime of the Barents Sea, which determines all the peculiarities of its hydrographical conditions, is, of course, the drift of Atlantic water (the North Cape current), flowing into the Barents Sea and dividing here into several ramifications. Fluctuations in the inflow of oceanic water occur from year to year. Consequently there occur fluctuations in the general physical conditions in the Barents Sea.

The beginning of the year 1929 was distinguished by an uncommon

diminution in the inflow of Atlantic water. Arctic conditions predominated in the Barents Sea, as is clearly shown by the results of the cruise in May 1929 (see KREPS and VERJBINSKAYA, 1930) — low water temperatures, an extremely southerly position of the ice margin etc. During the year 1929 and the following years 1930 and 1931 a gradual increase of the Atlantic influences in the Barents Sea may be observed. This can be illustrated by the temperature and salinity diagrams for similar seasons of the year.

It is natural to expect that two periods so different in respect to their hydrographic conditions will differ also in respect to the content of nutrient salts. We shall compare the same sections which were used for the comparison of temperatures and salinities, i.e. the September, December and March sections.

September. The typical late summer distribution of phosphates was observed in September 1929, as well as in September 1930. The surface layers were depleted of phosphates; the depths, on the contrary, were rich in them. Nevertheless some quantitative differences could be detected. The depletion of phosphates in September 1930 was greater than it was in September 1929. In September 1930 the phosphate content in the upper 25 metres nearly everywhere along the section did not reach 10 mg. per cubic metre, whereas in September 1929 the phosphate content in the upper 25 m. was above 10 mg. The shape of the isolines of phosphates in both Septembers was very alike, but the total amount of phosphates from top to bottom was less in September 1930 than in September 1929 (Table 3).

The comparison of nitrate distribution in both Septembers shows a complete analogy with that of phosphates, a similarity of distribution and a greater depletion in the upper layers with a general diminution in the store of nitrates in the 200 metre column of water.

The comparison of the winter pictures of the nutrient salt distributions also shows certain differences. At the end of December 1929, in spite of the winter vertical mixing, the distribution of phosphates and nitrates still showed some trace of layering, especially in the southern part of the section. In the winter 1930/31 the vertical circulation was probably proceeding more intensely, for at the beginning of January no traces of layering could be detected. As observed also in the year 1929, in the winter of 1930/31 the areas of Arctic water were richer in phosphates and nitrates than the regions of Atlantic water. The inshore waters were poorer than the Atlantic waters. The general store of phosphates was less in the winter of 1930/31 than in the winter of 1929/30 (Table 4).

Table 1. Mean temperatures of the stations and mean temperature of the section.

Date	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°	Mean of the Section
Autumn.															
15—21 Sept. 1929.	—	5.80	4.77	3.81	5.39	4.59	4.64	3.83	4.67	4.20	– 0.11	2.10	2.91	1.89	3.72
20—24 Sept. 1930.	—	4.73	5.19	4.52	5.41	4.81	4.76	4.08	5.18	4.26	1.61	3.28	4.11	3.69	4.28
Winter.															
22—29 Dec. 1929..	4.66	4.81	4.50	4.62	4.38	4.41	3.13	2.31	3.98	3.49	0.53	2.21	2.23	2.39	3.39
2—6 Jan. 1931.....	4.00	4.39	4.45	4.65	4.61	4.68	4.53	2.99	4.02	4.50	3.95	0.25	2.29	2.79	3.75

Table 2. Mean salinities of the stations and mean salinity of the sections.

Date	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°	Mean of the Section
Autumn.															
15—21 Sept. 1929..	—	34.56	34.55	34.61	34.77	34.86	34.96	34.93	35.03	35.03	34.72	34.76	34.84	34.82	34.81
20—24 Sept. 1930..	—	34.62	34.59	34.70	34.84	34.89	34.95	34.98	35.09	35.03	34.94	34.97	35.11	35.10	34.91
Winter.															
22—29 Dec. 1929..	34.37	34.58	34.64	34.77	—	34.92	34.88	34.91	35.03	35.01	34.85	35.00	34.98	34.98	34.85
2—6 Jan. 1931....	34.49	34.62	34.68	34.72	34.82	34.99	35.01	35.07	35.12	35.12	35.18	–	35.18	35.16	34.94

Table 3. Mean concentrations of P_2O_5 in the upper 200 metres.

Date	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°	Mean of the Section
15—21 Sept. 1929.	29.9	36.2	37.3	25.0	34.8	38.1	35.3	—	41.8	39.0	43.5	35.3	40.1	52.3	37.7
20—24 Sept. 1930.	—	21.1	21.2	25.0	23.9	24.1	27.4	29.1	29.6	26.9	36.6	29.4	28.9	27.2	27.1

Table 4. Mean phosphate content of the water column 0—200 metres.

Date	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°	Mean of the Section
22—29 Dec. 1929..	32.6	37.8	43.6	40.9	39.6	41.3	45.3	54.8?	46.1	40.0	—	36.5	40.1	43.9	42.1
2—6 Jan. 1931....	36.5	23.1	34.9	—	34.9	38.4	40.5	35.0	30.9	40.0	37.9	39.9	42.8	43.0	36.4

Table 5. Mean concentrations of P_2O_5 in the upper 200 metres.

Date	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°	Mean of the Section
28 March- 6 Apr. 1930..	35.9	36.6	39.5	46.2	42.7	44.9	48.1	45.0	51.4	53.1	50.0	50.0	50.0	47.3	46.2
19 –24 March 1931.....	32.4	22.6	41.0	39.1	28.6	—	35.6	46.8	40.5	29.0	28.2	35.3	37.6	44.8	35.2

The end of March 1931 was also different from the end of March 1930. At the very end of March 1930 no trace of vernal depletion of phosphates could be detected. On the contrary the March section of 1931 already showed some signs of a diminution in the phosphate content in the upper layers, especially in the vicinity of the areas of cold water (but not in the centres of the Arctic regions; see diagram, Fig. 8). Thus, an acceleration of the vertical mixing observed in the winter 1930/31 was accompanied also by an earlier beginning of vernal changes. The total amount of phosphates in the 200 metre column in 1931 was considerably less than it was at the same season of the preceeding year (Table 5).

The observed differences in the content and distribution of nutrient salts between the two years may be due to some extent to the greater Atlantic inflow in the year 1930/31.

The consumption of phosphates in the Barents Sea.

It is of interest to use the available data in an attempt to calculate the annual consumption of phosphates. By subtracting the consecutive values for the mean phosphate content of the whole water column we get an annual balance sheet. The quantity of phosphates in the water column decreases during spring and summer and increases again in autumn, because of the regeneration of inorganic phosphates. Of course, the regeneration also takes place in spring and summer, but it is masked by the predominant photosynthesis. In the course of time photosynthesis decreases and regeneration increases and at some moment an equilibrium of both phenomena — consumption and regeneration — is reached. This moment may not be the same at different positions in the sea. The vertical mixing does not interfere with the construction of the balance sheet. It does not matter where the regenerated phosphates are to be found at a given moment, whether they have already reached the photosynthetic zone or not.

Some other considerations are of greater importance: 1) The rate of regeneration of phosphates and 2) The movements of the water which, being considerable, may upset the validity of the phosphate cycle.

Use was made of the data given in the diagrams to ascertain the average phosphate concentration in the water column of 200 metres. (On stations lat. 70° and 75° N. the water column is only 150 metres deep.) The first column (Table 6) shows the phosphate concentrations at the beginning of April 1930, just before the vernal outburst of plant growth. The figures probably represent the maximal annual values. The results of the cruise in June show a marked consumption of phosphates

in the whole column of water. During this period (from April till June) the conditions of vertical mixing were still favourable and the upper strata depleted of phosphates were easily replaceable by water from the depths. The decrease in phosphate concentration is shown in table 7. The maximal decrease was observed on stations lat. 72°30′, 73°30′, 74° and 75° N.

The decrease in phosphate concentration continued from June till August at all points except lat. 72°, 73°, 73°30′ and 75° N. which showed an increase in phosphates. Stations lat. 73°, 73°30′ and 75° correspond to the Arctic streams. These stations were in advance in regard to the beginning of plant growth in spring as well as to the complete consumption of nutrient salts. But with respect to station lat. 72° a quite different explanation must probably be applied. The August diagrams of phosphate and temperature distribution (Fig. 4) show at this point a well defined wedge of cold water rich in nutrient salts, like the streams at 73° and 75°. This wedge of cold, deep water was not present at lat. 72° in June and it could not be detected again during the September cruise, whereas the stable and constant wedges of cold water at lat. 73° and 75° were always clearly pronounced.

The restitution of the phosphate content began in August. In September the increase in phosphates was considerable at all points except the above mentioned station lat. 72° N. and the Arctic stations, which were distinguished by no increment in phosphates or a very weak one. Probably a new consumption of nutrient salts took place, due to a secondary autumnal outburst of plant growth. The decrease in phosphates at lat. 72° may be explained by the disappearance of the above mentioned wedge of cold water rich in phosphates.

Some information about the rate of regeneration is supplied by the data for the months of September, November and January, when there is no more photosynthesis and regeneration is the only process going on. The regeneration of phosphates for subsequent periods is shown in table 6. Very probably the regeneration of phosphates during the 100 days from the August till the November cruise (10/VIII—20/XI) attained its maximal value, as this period approximates to the period of maximal production.

The duration of the vegetation period in the Barents Sea, as far as we know, is equal to nearly 100 days — from the beginning of May till the middle of August. Let us take it from 1 May till 10 August (the date of the August cruise). The decrease in phosphate concentration in the 200 metres layer during this period is given in the first column of table 8. The regeneration for the following 100 days (10 August –

Table 6. Mean phosphate concentrations in the water column 0—200 metres in different months.

Month	69°30	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°
March 1930.....	35.9	36.6	39.5	46.2	42.7	44.9	48.1	45.0	51.4	53.1	50.0	50.0	50.0	47.3
June 1930.....	21.8	19.0	23.8	28.5	30.6	27.0	27.7	27.4	27.3	28.0	30.1	26.7	34.0	31.9
August 1930.....	15.3	14.1	12.9	16.4	20.2	33.3	22.1	32.8	29.8	22.5	22.6	28.1	26.5	31.7
Sept. 1930.....	—	21.1	21.2	25.0	23.9	24.1	27.4	29.1	29.6	26.9	36.6	29.4	28.9	27.2
Nov. 1930.....	24.9	24.5	33.8	32.6	34.1	37.9	40.5	38.8	34.2	41.4	39.3	38.0	33.7	—

Table 7. Changes in the phosphate concentrations of the water column 0—200 metres from cruise to cruise.

Period of time .	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°
from March till June	—14.2	—17.6	—15.7	—17.7	—12.2	—17.9	—20.4	— 17.6	—24.2	— 25.1	—19.9	—23.2	—16.0	—15.3
from June till August....	— 6.4	— 4.8	—10.9	—11.6	—10.4	+ *6.4*	— 5.6	+ *5.4*	+ *2.4*	— 5.5	— 7.4	+ *1.0*	— 7.5	— 0.2
from Aug. till September .	—	+ 7.0	+ 8.3	+ 8.2	+ 3.7	— *9.2*	+ 5.2	— *3.7*	— *0.2*	+ 4.4	+13.9	+ 1.0	+ 2.4	— *4.5*
from Sept. till November.	—	+ 3.4	+12.5	+ 7.6	+ 10.2	+13.8	+13.1	+ 9.6	+ 4.6	+ 14.6	+ 2.8	+ 8.6	+ 4.8	..
from Aug. till November .	+ 9.5	+10.4	+20.8	+ 15.8	+13.9	+13.8	+18.3	+ 9.6	+ 4.6	+ 19.0	+16.7	+ 9.6	+ 7.2	..

Table 8. Consumption and regeneration of phosphates.

	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°
The decrease in phosphates during vegetation period	20.6	22.4	26.6	29.3	22.6	27.1	26.0	21.3	24.4	30.6	27.3	23.2	23.5	15.5
Regeneration of phosphates during 60 days	5.7	6.2	12.5	9.5	8.3	13.8	10.9	9.6	4.6	11.4	10.0	6.0	4.3	—
Consumption during the vegetation period	26.3	28.6	39.1	38.8	30.9	40.9	36.9	30.9	29.0	42.0	37.3	29.2	27.8	—

Table 9. Production of phytoplankton and of glucose sugar along the Kola meridian. (Tons per square kilometre).

	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′
Phytoplankton production (wet weight) corrected for regeneration	3.500	2.860	5.200	5.150	4.100	5.480	4.920	4.120	3.860	5.600	4.920	2.920	3.700
Carbohydrate formation (as hexose) corrected for regeneration	525	428	780	772	615	822	738	618	579	840	738	438	555
Phytoplankton production minimal values	2.750	2.240	3.550	3.910	3.000	3.620	3.460	2.840	3.250	4.080	3.650	2.320	3.130
Carbohydrate formation minimal values	413	335	533	586	450	543	520	426	487	612	548	348	470

20 November) is shown by the figures of the second column (Table 8).

The rate of phosphate regeneration during the period of vegetation is very probably not so high. It is reasonable to assume that in the first weeks of photosynthetic activity, when the zooplankton is not yet abundant, and when the phytoplankton is not yet dying and sinking in great masses, the rate of regeneration is much slower than later on, when there is an enormous amount of newly formed material for decomposition and mineralisation. Therefore we take the regeneration of phosphates during the 100 days of vegetation as equal to only 60 % of the regeneration taking place during the following 100 days (10/VIII—20/XI). Adding this correction for regeneration to the figures of column 1, we get the amount of phosphate consumed during the period of vegetation — column 3. The values of the phosphate consumption without the correction for regeneration we shall call "minimal values".

Stations lat. 72°, 73° and 73°30′ N. require to be specially noticed. Due to the above mentioned peculiarities of the phosphate cycle at these places, the annual consumption of phosphates was calculated by adding the figures for decrease in phosphates in March—June to the figures for decrease in August—September.

The figures in table 8 show that the annual consumption of phosphorus is not uniform along the section. There are points of maximal and points of minimal production of phytoplankton. The minima correspond to stations lat. 69°30′—70°, 73°—73°30′, 75°—75°30′ N. The maxima to lat. 70°30′, 72° and 74° N. Comparison with the temperature diagrams shows clearly that the areas of maximal production are the regions of mixing of Atlantic and Arctic waters. These areas are the border regions between the cold polar water and the warm Atlantic streams. In other words, the maximal consumption of nutrient salts was observed at those places at which the section crossed the so-called "polar front" (A. Defant, 1928. See also Wattenberg, 1930.).

A knowledge of the phosphate consumption enables an estimate to be made of the annual phytoplankton crop (Atkins, 1926). Taking the phosphate content of the phytoplankton as 0.15 %, calculated on the wet weight (as for the brown algae), it results that the whole column of water produces the quantities of phytoplankton per annum per square kilometre shown in table 9. If it be assumed that the carbon content of the algae, reckoned as hexose sugar, amounts to 15 % (Atkins) of the wet weight, we get the amounts of carbohydrates produced per annum per square kilometre given in table 9.

All these considerations take no account of the part played by

bacteria in the consumption of nutrient salts in the sea. Our knowledge is still insufficient for a quantitative evaluation of the rôle of bacteria in the cycle of events, but all the data avaiable (Butkevitch) suggest that their importance must be considerable and has not to be neglected.

Atkins estimates for the 70 metre water column at the international station E1, off Plymouth, an annual phytoplankton crop of 1400 metric tons of wet weight per square kilometre. Gran (1930) observed the rate at which oxygen increased in a flask of sea water suspended in Oslo fjord in March, due to the photosynthesis by the included phytoplankton. If this is taken as a measure of the photosynthesis occurring in the upper 10 metres of the sea, it is comparable with the daily formation of 2.4 metric tons of glucose sugar per square kilometre, i.e. 240 tons per 100 days of the assumed vegetation period. The estimates of the phytoplankton crop for the Barents Sea are thus considerably greater than the estimates for the English Channel and Oslo fjord. This agrees well with the well-known abundance of animal and plant life in the northern seas and particularly in the Barents Sea.

The richness of northern waters may be considered as due, *inter alia*, to the better vertical circulation than in the temperate zone, and also to the fact, which becomes more marked in high latitudes, that since light is the limiting factor for plant growth for a considerable portion of the year, the water accumulates a greater store of phosphates. Then when daylight returns or lengthens its duration, a great outburst of the phytoplankton takes place.

The richness of the Barents Sea in food fishes, which attracts the interest of all the maritime nations, is based, of course, upon the formidable production of organic matter by the phytoplankton activity.

Summary.

1) The data reported here give a detailed picture of the seasonal changes and the distribution of nutrient salts in the Barents Sea, with some information about the fluctuations from year to year.

2) The depletion of nutrient salts reaches its maximum in August. At this time the concentration of phosphates, as well as of nitrates, in the photosynthetic zone falls to zero. The re-establishment of the phosphate and nitrate content begins at the end of August. The rate of the re-establishment is maximal during October—November.

3) The Arctic and the inshore waters in the Barents Sea are always

in advance in regard to the seasonal changes, as compared with the Atlantic waters.

4) The Arctic water is richer in nutrient salts than the Atlantic water. The inshore waters, again, are poorer in them than the Atlantic waters.

5) The year 1930/31 differs from the year 1929/30 by reason of a greater inflow of Atlantic water, a decrease in the general store of nutrient salts, an earlier turn-over of the water in winter, an earlier beginning of the vernal consumption of nutrient salts.

6) An estimate of the annual phytoplankton crop is made, based on the consumption of phosphates. The phosphate content of the phytoplankton was assumed to be 0.15 %, calculated on the wet weight. The estimates of the phytoplankton production are nearly twice as great as the estimates of Atkins for the English Channel and of Gran for Oslo fjord, i.e. 3000—5000 tons of wet weight of phytoplankton per annum per square kilometre.

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Observations on the Nitrite Changes in the Barents Sea.

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The present contribution deals with some data regarding the seasonal distribution of nitrites in the Barents Sea along the Kola meridian, collected during the cruises of the "Nikolai Knipovitch" in the year 1930. Being only a part of the general work upon chemistry, hydrography and biology of the Barents Sea, these data are published separately only because of the scarcity of our knowledge about the nitrite changes in the open sea.

The observations were made on 7 cruises along the meridian 73°30′ E., from the sea shore as far as the ice margin, in December 1929, March, June, August, September, November 1930 and January 1931.

The nitrites were determined by the Griess colorimetric method. All the determinations were made on board as soon as the samples of water were collected. The colour comparison was made in Heyner tubes, 30 cm. long, fixed on a stand in such a way as to enable 4 samples to be compared concurrently. One of the tubes was filled with distilled water, which made it possible to notice the presence of a very faint tint.

The seasonal distribution of nitrites was as follows. In December 1929 the nitrites could not be detected anywhere along the section. In some places a very faint coloration of the samples was observed, but the intensity was so weak that it was quite impossible to make any quantitative evaluation.

At the end of March 1930 the nitrites appear evenly distributed in the water column, but their concentration is very low, never exceeding 0.3 mg./m^3.

In June, at the time of the intense consumption of phosphates and nitrates, the nitrites appear in considerable, readily measurable quantities. Together with the increase in the concentration of nitrites, a peculiarity in their distribution may be observed. The maximal content of nitrites was found in the 50—100 m. layer, where their concentration reached 0.5—2.0 mg./m.³. In the regions of water of Atlantic origin the nitrite content was higher and the distribution in the water column more even. On the most Arctic stations, close to the ice margin, the nitrites could be found only in the intermediate 50—100 m. layer.

In August the peculiar distribution of nitrites was still more pronounced. Nearly all the nitrites were confined within the 50—100 m. layer. In the surface water, as well as in the bottom strata, the nitrites were entirely absent or their content was very low, whereas in the 50—100 m. layer, especially at 50 m. depth, the content of nitrites sometimes reached 14 mg./m³.

The September cruise showed no further development of the summer picture in nitrite content and distribution. The distribution of nitrite in September is rather a transitional state to the winter one. The concentration of nitrites had decreased, to 1—2 mg./m³. on the average. In certain places only the nitrite content reached 3—6 mg./m.³. The peculiar summer distribution could be detected only on the northernmost stations, to the north of Lat. 76°30′ N., where the nitrites were still collected in the 50—100 m. layer. All the remaining (southern) part of the section showed a rather even vertical distribution of nitrites, with only a slight increase at 50 metres.

In November (18—25) no nitrites could be detected anywhere along the meridian, with the exception of the northernmost stations in 75° and 75°30′ N., where they were found in very low concentrations (0.1—0.2 mg./m³.) in the 25—50 m. layer.

In January (2—8) 1931 the nitrites totally disappeared on the Kola meridian.

We are sorry to state that no parallel determinations of ammonia were made, which of course materially decreases the value of the nitrite data.

The comparison of the nitrate and nitrite changes (see Kreps and Verjbinskaya, 1 and 2) permits us to reach certain conclusions. The nitrites appear at the time when the nitrates begin to be utilised by the photosynthetic activity of phytoplankton (in June). Concurrently with the decrease in nitrates there is an increase in nitrites, which accumulate in the 50—100 m. layer. At the time of the lowest nitrate content (August), when the nitrates are totally used up, the nitrites reach their maximal values.

Table 1. The distribution of nitrites, June 4—10, 1930. Kola meridian.

Depth	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	76°30′
0 m.....	—	0	0.35	0.98	1.0	0.72	0.71	0	0	0.43	traces	0	0
25 -	—	0.66	0.50	0.98	1.14	0.81	0.73	traces	0	1.16	0.60	0	0
50 -	—	1.53	0.79	1.26	1.20	1.15	1.0	0.76	1.0	1.51	0.68	0.75	2.43
100 -	—	1.06	0.26	1.86	1.96	1.33	2.25	1.19	1.43	1.51	2.33	0.73	3.11
200 -	—	—	0.17	1.10	1.20	1.33	1.69	0.57	1.40	1.33	0.44	0.83	0
bottom.....	—	2.10	0.15	0.79	1.30	0.57	1.24	—	traces	0.32	0.28	—	0

Table 2. The distribution of nitrites, August 8—16, 1930.

Depth	69°30′	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°	30′
0 m.....	0	0.2	0	0	0	0	0	0	0.9	1.1	0	0	0	0	0
25 -	1.1	0.2	0	0	1.1	1.0	0	2.6	1.4	1.1	0	0	0	0	0
50 -	1.6	2.5	0	6.3	4.6	5.2	2.7	14.7	11.3	5.1	3.3	2.6	6.4	7.8	4.3
100 -	1.6	2.5	5.3	0	4.2	0	4.6	0	0	0	1.6	2.3	4.8	2.7	0.8
200 -	1.9	—	0	0	0.3	1.3	1.9	2.0	2.4	3.0	1.3	—	0.7	0	—
bottom	2.0	—	0	0	1.5	1.1	0	2.6	0	1.2	1.0	2.2	0.9	0	0.7

Table 3. The distribution of nitrites, September 20—24, 1930.

Depth	70°	30′	71°	30′	72°	30′	73°	30′	74°	30′	75°	30′	76°	30′	77°
0 m.	0.2	0.3	0.4	0.5	0.4	0.5	1.7	0.4	1.3	1.1	0.6	1.9	1.6	2.1	0
25 m.	0.2	0.3	0.4	0.6	0.5	0.6	2.1	1.4	1.5	1.1	0.7	2.1	1.9	2.0	0.6
50 -	1.2	0.7	1.0	1.3	0.6	0.6	3.5	1.3	1.8	3.1	1.1	2.1	traces	6.7	6.0
100 -	0.3	0.2	0.4	0.4	0.3	0.4	0.5	traces	0	1.7	0	0	,,	3.2	2.5
200 -	—	—	—	0.5	—	traces	0.7	,,	0.8	—	0.6	0	,,	0.6	—
bottom	0.3	0	0.4	0.4	0.3	0.3	1.6	,,	0.7	0.9	0.6	0	,,	0	0

Table 4.

Depth	24 December 1929	2 April 1930	7 June 1930	11 August 1930	22 September 1930	21 November 1930
0 m.....	0	0.1	0.7	0	0.5	0
25 m.....	0	0.1	0.7	0	0.6	0
50 -	0	0.1	1.0	2.7	0.6	0
100 -	0	0.1	2.3	4.6	0.4	0
200 -	0	0.1	1.7	1.9	traces	0
bottom	0	0.2	1.2	0	0.3	0

The regeneration of nitrates is followed by a decrease in nitrite concentration. In September the nitrates already begin to appear in the upper strata and the nitrites show a marked diminution. Finally, towards November, when the stock of nitrates is nearly totally restored, the nitrites fall to zero (see Fig. 1).

At the present state of knowledge of the nitrogen balance in the

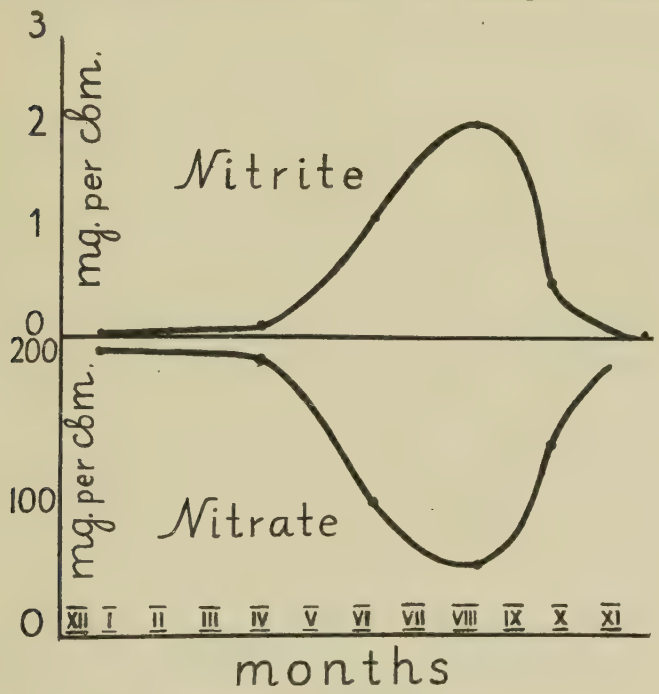

Fig. 1. The mean content of nitrites and nitrates in a water column 0—100 m. in different months in 1930. Barents Sea. Position Lat. 72°—72°30′ N. Long. 33°30′ E.

sea it is not easy to say whether the nitrites are to be considered as the products of ammonia oxidation or of the reduction of nitrates. The observed seasonal changes in the Barents Sea agree well with ATKINS' opinion that the nitrites in sea water exist only as a temporary, intermediate stage in the process of ammonia oxidation. The nitrites appear in noticeable amounts at the time of the increase in phytoplankton growth, when the dead and decaying organisms begin to supply enough matter for ammonia formation, followed by a production of nitrites. The maximum of nitrite content coincides with the complete exhaustion of nutrient salts in the sea, i.e., with the time when the store of decaying protein matter is enormous. And, according to the rise in nitrate con-

tent, the nitrites gradually diminish. As soon as nitrification ends, the nitrites disappear totally from the Barents Sea.

Table 4 shows the content of nitrites in different months at station 72°30′ N. 33°30′ E.

The solution of $NaNO_2$ which served as standard for comparison was made on distilled water. As a result the nitrite data are perhaps too high, as the coloration developed by the nitrites in distilled water is weaker than the coloration developed in sea water.

Summary.

1) The seasonal changes in nitrite distribution in the Barents Sea agree well with Atkins' observations in the English Channel.

2) The nitrites appear in the Barents Sea in spring concurrently with the onset of phytoplankton growth, increase during the summer months and decrease again in autumn. Towards November the nitrites completely disappear from the water.

3) The maximal content of nitrites was observed in August, when the nitrates were at their minimum.

4) The maximal concentration of nitrites was found at 50—100 m. depth.

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(3) Atkins, W. R. G. Seasonal Changes in the Nitrite Content of Sea-water. Journ. Mar. Biol. Assoc. XVI, 515, 1930.

(4) Orr, A. P. The Nitrite Content of Sea-water. Journ. Mar. Biol. Assoc. XIV, 55, 1926.

The Influence of Light on the Cod.

By

Alf Dannevig.

Flødevigen, Norway.

At the Flødevig Sea-Fish Hatchery it is well known that in their early stages the cod fry are greatly affected by the intensity of the light.

During dark, cloudy, and especially foggy weather, the fry appear to become relatively heavy and tend to sink even when the specific gravity of the water is somewhat higher than that ordinarily found for such fry (about 1.021). At the same time they turn pale, the chromatophores are contracted and the eyes loose their brilliance. When the air is bright and the sun shining, the young fish are lively and healthy in appearance, as is only very natural.

This tendency to sink in cloudy weather increases during the night. Before dawn especially, the young fish may sink to the bottom of the hatching apparatus[1]) in the same water in which they are able to swim during the day. Their activity and vigour are diminished.

This sinking is particularly noticeable when the water circulation is shut off. The fry soon accumulate on the bottom, and if they are not made to come up, they die.

The cod larvae, however, react by sinking to numerous influences, such as cold, heat or mechanical injury brought about, for example, in the transport boxes in rough weather. Some simple experiments were therefore undertaken in order to determine whether lack of light was the principal cause.

[1]) For the description of apparatus and methods see G. M. Dannevig: "Apparatus and methods employed at the Marine Fish Hatchery at Flodevig, Norway", Washington, 1908, and Alf Dannevig: "Die Kultur von Meeresfischen in Norwegen". Mitteilungen des Deutschen Seefischerei-Vereins, 1928, Berlin, 1928.

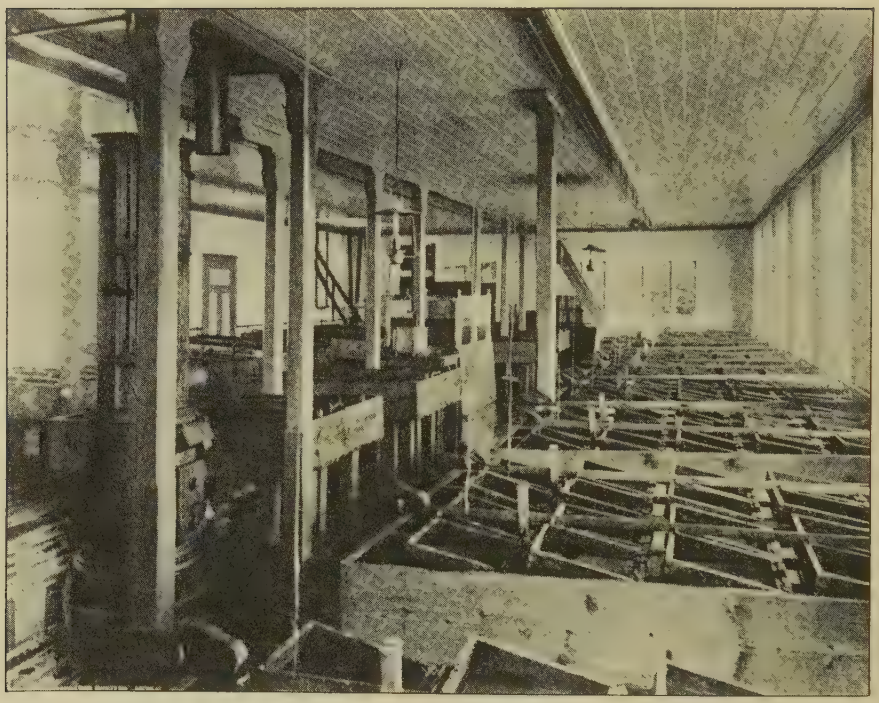

Fig. 1. The hatching room, with the glass aquarium in the middle.

Fig. 2. The hatching boxes. The cod fry, about 5 days of age, are seen close to the surface.

A first trial was made by placing an iron bath of sea water containing heavy fry directly under an ordinary electric lamp (Osram). The larvae became active at once and left the bottom layers for the surface. They also lost their paleness and regained their normal colour. The same result was obtained when an electric lamp was taken on the motor cutter lying at the quay and placed over one of the transport boxes in which the fry had become heavy during loading.

A few only of the experiments carried out will be described here;

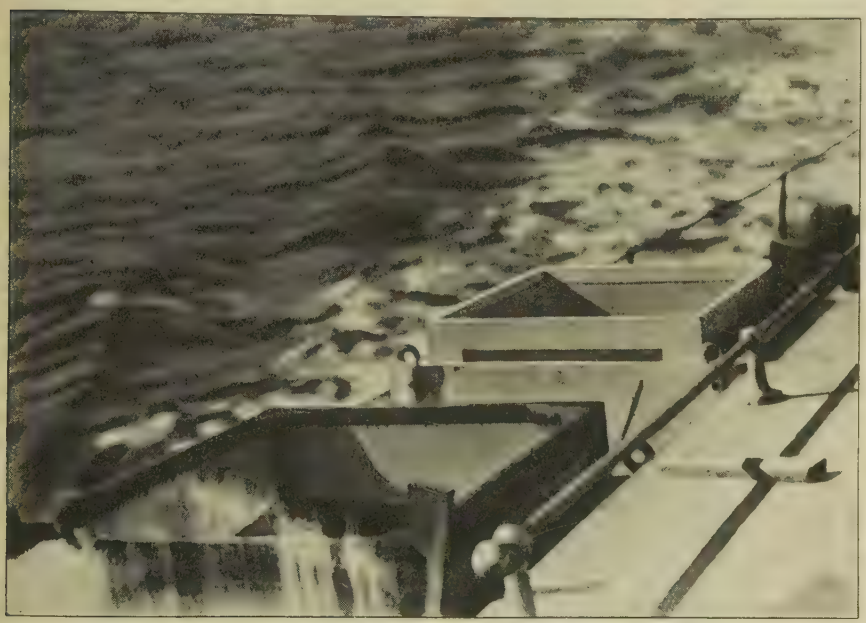

Fig. 3. The transport boxes on the deck of M/C. "Ossian Sars".

a full account will be given in the annual report of the hatchery ("Flødevigens Utklekningsanstalt, beretning for terminen 1930/1931" av Bestyrer Alf Dannevig. Norges Fiskerier, Bergen. In the Press). For this work, a galvanized iron bath, 75 × 56 × 30 cm., was used, painted white at one end and black at the other (Fig. 4).

Experiment A.

On 6th April, 1930, the bath was placed in the laboratory near a window facing south, with the diversion between the two colours parallel to the direction of the light entering. The bath was filled to 9 cm. from the edge with sea water of specific gravity 1.0227 and temperature 4.6° C. The weather was dark and rainy. At noon some fry, 4 to 5 days old,

were placed in the bath, and in few minutes they had crowded to the white end. The fry were left in the bath over night.

The next day the weather was foggy. At 10.35 a.m. the larvae had collected in the white end of the bath. The water was then gently stirred. At 10.45 the circulation was quite slow. The larvae swam towards the

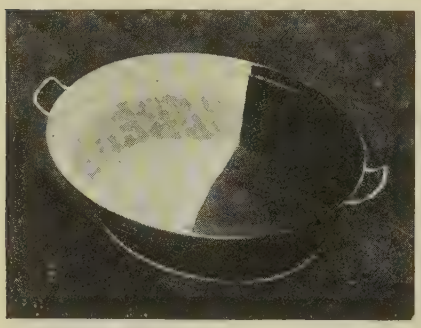

Fig- 4.

Fig. 5.

Fig. 4. The bath used for the experiments.

Fig. 5. The cod larvae are seen in the white compartment of the bath, on the left side best illuminated by the "Vitalux" lamp.

white compartment of the bath, on one side assisted by the current, on the other they were swimming against it. At 10.50 one individual was closely observed. From the centre of the bath it took 4 minutes to reach the white wall. The current was contrary, but very slow.

The larvae accumulated along the white part of the wall which received most light from the window. At 11.05 nine-tenths of the fry had collected in the white end.

Experiment B.

On 9th April the sky was cloudy and the air somewhat misty. In the forenoon, when the bath was placed in the open air, the larvae first congregated in the white end but then gradually spread over the whole area. The explanation probably is that in this case most light came from directly above.

Experiment C.

On 16th April the bath was placed in the hatching room, which has windows on all four sides, most light entering from the south and west. A strong electric lamp (500 W. "Vitalux", A/S Osram, without reflector) was placed 3 metres above the bath and 1 metre to one side. The "Vitalux" lamp is claimed to give light of wave-lengths between 4000 and

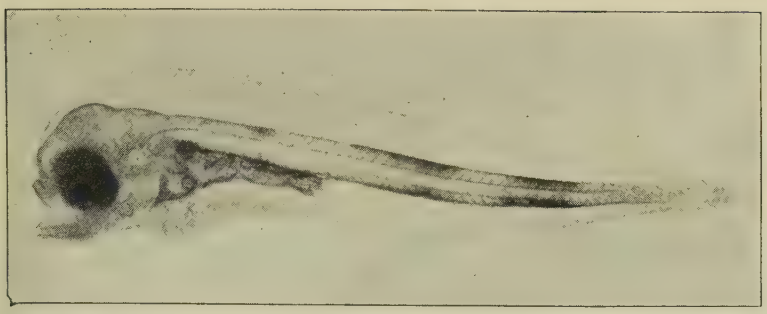

Fig. 6. Cod larvae about 5 days of age as used for the experiments.

270. At 5.30 a.m. some very heavy fry were placed in the bath. The specific gravity of the sea water was 1.0229 and the temperature 6.0° C. The fry at once revived, and at 6 o'clock four-fifths of them were congregated in the white end of the bath and were very lively. At 7.30 nearly all the fry remained near the surface, in the whitened part. With the advent of daylight, however, the larvae tended to spread throughout the water. At 10 o'clock a photograph was taken. In Fig. 5 the fry may be seen mainly in the white end, on the side best lighted by the "Vita-

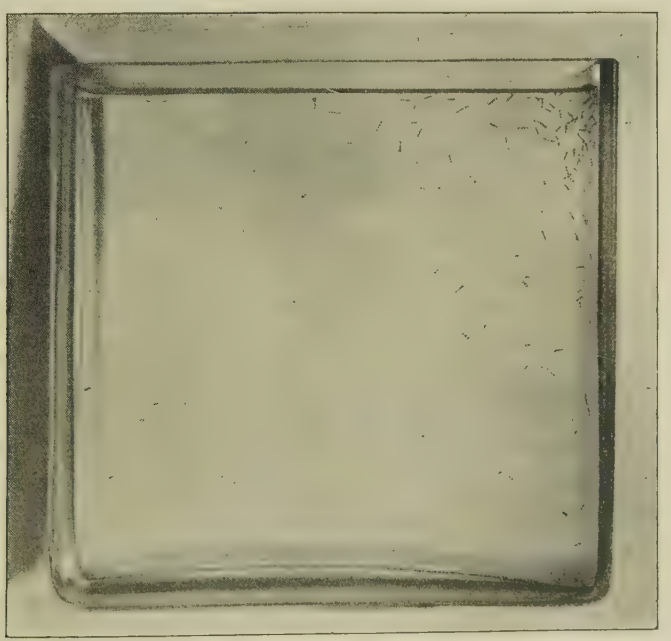

Fig. 7. A glass box with sea water containing cod larvae. The light comes in from the right, the left-hand side being screened.

lux" lamp. The flash light used for the photograph was to the left of the camera, the "Vitalux" lamp to the right.

As the daylight grew the larvae spread all over the bath. In the evening, however, when the daylight fell off, the larvae once more collected where the light from the "Vitalux" lamp was strongest.

Fig. 8. The spawning cod seek the electric light.

In the middle of the hatching room is a glass aquarium (see Fig. 1) in which some cod fry were placed. During the night some of the larvae (and a few copepods) accumulated near the surface immediately beneath the "Vitalux" lamp. During the day, however, both approached the glass wall facing the windows from which the strongest light came. When the daylight fell off they once more sought the artificial light. Similar behaviour was noticed for several days.

Fig. 7 is a photograph of a small glass box containing fry, which may be seen to have collected on the side at which the light enters.

The preceding examples show that cod fry about 4 to 8 days of age exhibit a positive phototaxis. In the bath they seek the best lighted wall, in the glass jars they seek the source of the light. I have also often

noticed, however, that the light is apparently too intense. When the sunbeams strike the water in the transport boxes on deck, the larvae may sink and leave part of the water entirely. I am, however, unable to ascertain if the light is the sole factor active in this case. It may be that the heat absorbed, in the chromatophores especially, may be of importance also. The sea water does not become hot enough to explain the sinking of the larvae.

It is thus apparent that the intensity of light has an important effect on the well-being of the very young stages of the cod.

The grown cod in our spawning pond also show phototaxis, with light of moderate intensity. Our spawning pond is protected by galvanized iron roofing, and by day the cod keep away from the doors through which light enters the pond. At night, however, they gather round one of the openings where a 25 W. Osram lamp is alight during the night about 3 metres from the surface. Fig. 7 illustrates the crowding of the fish.

One evening, when I put on the "Vitalux" lamp, the cod at once disappeared and did not return till the ordinary lamp was replaced. They evidently did not appreciate so much light and the interruption of their natural routine!

Is the Number of Vertebrae in the Cod influenced by Light or High Temperature during the Early Stages?

By

Alf Dannevig.

The Flødevig Sea-Fish Hatchery, Norway.

In spring, 1930, a number of cod larvae about 4 days of age were used for experiments on the influence of artificial light on the behaviour of the fish. These fry were afterwards liberated in our salt-water pond and reared.

On 20th November, 1930, 40 young fish were taken from the pond for examination in different ways.

The following table gives the number of vertebrae in the fish from

Fig. 1. The salt water pond at Flødevigen emptied for cleaning. Some of the oysters reared there may be seen on the walls and bottom.

the pond and also values for cod from the sea near Flødevigen. It will be seen that the values for the pond are exceedingly low, lower, indeed, than any found in the literature. (JOHS. SCHMIDT: Raceundersøgelser. "Den Atlantiske Torsk (*Gadus callarias* L.) og dens lokale Racer". Medd. fra Carlsberg Laboratoriet, Nr. 6, Kjøbenhavn, 1931. ERIK M. POULSEN: Biological investigations upon the cod in Danish waters". Medd. fra Kommissionen for Havundersøgelser. Serie Fiskeri. Bind IX, Kjøbenhavn, 1931.) They are also distinctly lower than those obtained from any samples examined by us from the fjords on the Norwegian Skagerack coast.

In counting the vertebrae we reckon only the vertebrae normally developed. The Danish scientists, however, include the posterior modified vertebrae as well. For comparison with ours the Danish figures must be reduced by one.

No. of Vertebrae	The Pond	Flødevigen
44	1	..
45	..	..
46	..	..
47	1	..
48	4	..
49	11	2
50	16	41
51	7	137
52	..	65
53	..	5
No. Examined:	40	250
Average:	49.48	51.12

It may be presumed that the number of vertebrae has been influenced by the artificial light in the laboratory, or by the conditions in the pond. The pond was at that time filled with ordinary sea water from 15 metres depth in the bay. As the pond is shallow, 5 metres being the greatest depth, the intensity of light is everywhere high, and the young fish cannot retreat to deeper water as they do when at large. Furthermore, the temperature in summer is higher than in the sea.

The low number of vertebrae in the cod from the pond is in full conformity with the results arrived at by Prof. SCHMIDT; the number of vertebrae diminish from the ocean towards the coast and into the

fjords. It is then very likely that the lowest values would be found in the pond.

It would be of value to study this problem by hatching the eggs of known parents, the vertebrae of which might be ascertained later, and by rearing the larvae under different conditions, an experiment which will be undertaken at Flødevigen as soon as means are available.

Die Turbinen und die abwärts wandernden jungen Lachse und Forellen.

2. Teil.

Von

C. V. Otterstrøm.

Dän. Biol. Station, Abt. Frederiksdal.

Im VI. Bande dieser Zeitschrift (Seite 273—286) habe ich über einige im Jahre 1930 vorgenommene Versuche berichtet, die angestellt wurden, um die Frage zu beleuchten, ob junge Lachse und Forellen von der bei der Abwanderung üblichen Grösse (ca. 10—20 cm) unbeschädigt Turbinen passieren können. Dabei wies ich auch hin auf die direkte Ursache für die Untersuchung dieses Problems bei uns — nämlich die 1927 vorgenommene Untersuchung der Sneum Aa und der Kongeaa mit Zuläufen zwecks Feststellung ihrer Eignung für die Aussetzung von Forellenbrut — zeigte gleichzeitig, dass es ein Irrtum sei, die Wanderung von Fischen durch Turbinengitter verhindern zu wollen, und erörterte schliesslich die diesbezüglichen ausländischen Versuche. Ich kann daher hier gleich dazu übergehen, einige weitere Versuche zu schildern, die die Biologische Station im Jahre 1931 machte. Sie wurden an drei Turbinen vorgenommen, die alle an der Holsted Aa liegen, einem Zufluss der Sneum Aa.

1. Bramminge Hovedgaard (Versuch vom 26/IX 1931).

Die Fallhöhe ist ca. 1,2 m. Die Turbine (System Mahler, 14 PS) liegt wagerecht auf dem Boden der cementierten Turbinenkammer; unter dem Boden ist kein Saugrohr. Es war daher nicht möglich, einen Fangbeutel direkt unter der Turbine zu befestigen, und der Wiederfang der Fische musste in das Hinterwasser verlegt werden.

Von der Turbinenkammer lief eine cementierte Wand auf jeder Seite des Hinterwassers ein Stück hinunter. Zwischen diesen Cementwänden wurde ein Holzrahmen eingekeilt, der eine hierfür besonders konstruierte Reuse aus Garneelennetz trug. Die Reuse war erheblich grösser als der 1930 verwendete Fangbeutel: sie war nämlich darauf berechnet, rechtwinklig über den Holzrahmen ausgespannt zu werden (ca. 212 cm × 150 cm); ausserdem sollte sie gebraucht werden können (siehe später), um auf ein Saugrohr mit einem Durchmesser von ca. 1,2 m aufgebunden zu werden. Sie war so lang, dass ihr äusserster Teil frei vom Saugrohr hinabhängen und nachgesehen werden konnte, ohne dass deshalb die

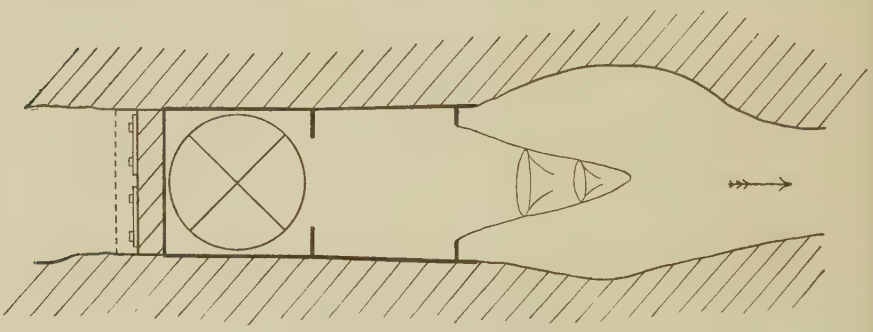

Fig. 1.
Bramminge Hovedgaard. Schematischer Riss der zeigt, wie die Turbine und die Versuchsreuse angebracht sind. Von links: Gitter, Stauwerk mit zwei Schützen, Steg, Turbinenhaus mit Turbine, der oberste Teil des Hinterwassers mit zementierten Seitenwänden, die auf einem eingekeilten Rahmen angebrachte Reuse.

Reuse abgebunden zu werden brauchte; ferner war sie mit zwei Kehlen versehen, die jedoch etwas spitzer hätten sein müssen, damit die Fische leichter hätten in die Reuse zurück gespült werden können.

Nachdem der Holzrahmen mit der Reuse angebracht worden war, wurde das unregelmässige Loch unter der untersten Latte gedichtet mit strohgefüllten Säcken, die, um am Boden liegen bleiben zu können, innen an der einen Seite mit Steinen beschwert waren; aber trotz aller angewandten Mühe können Löcher nachgeblieben sein, durch die Forellen hindurch schlüpfen konnten.

Ein Trichter (Jauchepumpentrichter) wurde mit der unteren Öffnung zwischen zwei Leitschaufeln auf der am Boden der Turbinenkammer liegenden Turbine angebracht und zur Sicherung seiner Stellung festgebunden.

Versuchsfische wurden von der Teichwirtschaft von Bramminge Hovedgaard geliefert und in Eimern bereit gehalten.

Die Turbine wurde darauf in Gang gesetzt, und als es sich gezeigt hatte, dass die Säcke trotz des Wasserdruckes in ihrer Lage blieben, und dass trotz Anwendung der Jagestange kein Fisch in die Reuse ging (also wahrscheinlich keine im voraus vorhanden waren), begann der Versuch, nachdem die Turbine wieder gestoppt worden war.

Die Turbine wurde wieder in Gang gesetzt. Darauf wurden 50 Regenbogenforellen von 8—14 cm (zumeist 10 cm) durch den Trichter in die Turbine geschüttet und ein par Eimer Wasser nachgegossen, damit kein Fisch in dem Trichter stehen blieb. Ohne die Turbine zu stoppen, wurde die Reuse untersucht, aber trotzdem die Fische ihr durch Staken zugetrieben wurden, enthielt sie nur 14 Fische. Sie lebten alle; zwei waren freilich verschlagen (der eine hatte Exophthalmus), doch waren sie lebensfähig. Die Turbine wurde gestoppt.

Nachdem die Turbinenschützen wieder aufgezogen worden waren, wurden 50 Regenbogenforellen von 16—21 cm (die meisten 19—20 cm) durch den Trichter hinunter geschüttet und wieder nachgespült. Vor der Reuse wurde gestakt und während die Turbine weiter lief, wurde die Reuse aufgenommen. Es zeigte sich, dass sie 5 Fische von dem ersten Satz (alle unbeschädigt) und 38 von dem zweiten Satz enthielt; von diesem letzten trugen 8 Fische strichförmige Merkmale von Schlägen oder Hautabschürfungen — doch waren sie in keinem Falle so stark, dass die Fische dadurch weiter beeinflusst schienen, und in keinem Falle bildeten sie offene Wunden.

Die nicht wieder gefangenen Fische müssen entweder zwischen den Dichtungssäcken hindurch geschlüpft sein, oder sie haben sich (worauf der Fang der 5 Fische des ersten Satzes im zweiten Teil des Versuches schliessen lässt) abseits in ruhigerem Wasser unter der Turbinenkammer aufgehalten, von wo sie nicht mit der Jagestange vertrieben werden konnten. Man muss annehmen können, dass alle fehlenden Fische zur Hauptsache unbeschädigt gewesen sind, denn sonst wären sie mit dem Strom in die Reuse getrieben worden. Auch wurden keine toten Fische bemerkt, als die Reuse mit den Säcken aufgenommen wurde, und sie hätten nicht gut der Aufmerksamkeit entgehen können. Die beschädigten Fische wurden zur Aufbewahrung in einen Teich gesetzt; keiner ging später als Opfer der Beschädigung ein: der Versuch ergab also als Sterblichkeit infolge Durchgang durch die Turbine 0 %.

Es sei hinzugefügt, dass die Turbine mit normaler Wasserzufuhr lief, aber nicht mit Arbeit belastet war und daher schneller lief als normal, was indessen eher eine erhöhte Gefahr für die Forellen bedeuten dürfte.

2. Holsted Mühle (Versuch vom 28/IX 1931).

Die Turbine, die 1905 von Frichs Fabriken, Aarhus, geliefert ist, besitzt 18 PS. Sie liegt wagerecht auf dem Boden einer Kammer, deren

Fig. 2.
Holsted Mühle vom Hinterwasser gesehen. Es sind nur wenige Centimeter zwischen der Wasseroberfläche und dem Eisenbalken, der die Mauer der Turbinenkammer trägt und unter dieser sichtbar ist.

Unterseite mit dem Saugrohr nur von einer Seite her zugänglich ist; die Öffnung des Saugrohrs liegt überdies, bei normalem Wasserstand im Hinterwasser, nur wenige Centimeter über der Wasserfläche. Die Fallhöhe beträgt 1,7 m.

Nachdem die Turbinenschützen eingesetzt worden waren, sank der

Wasserstand im Hinterwasser während einer Viertelstunde so viel, dass ein Mann nur eben mit dem Kopf über Wasser unter dem Rahmen hindurch kriechen konnte. Aber es zeigte sich, dass das Saugrohr soviel Platz nahm, dass der Mann weder seitlich davon noch dahinter ankommen konnte und daher die Reuse nicht anzubinden vermochte. Die Möglichkeit, mit dem Kopf im Saugrohr zu stehen und dann die Reusenmündung um die Rückseite des Rohres zu führen, war ausgeschlossen, weil die Turbine ständig in Gang war; sie wurde nämlich von einem Hilfsmotor mitgezogen, der aus Rücksicht auf den Betrieb nicht eingestellt werden konnte. Im übrigen zeigte es sich, dass sich senkrecht neben dem Saugrohr eine Eisenstange befand und dass diese es unmöglich machen würde, die Reuse ordentlich fest zu binden. Man musste also auf den ursprünglichen Plan, die Reuse fest zu binden, verzichten; und da auch keine rechte Möglichkeit bestand, die Reuse auf einem Rahmen im Hinterwasser anzubringen (jedenfalls nur mit grossen Vorarbeiten, die damals unmöglich waren), wurde der Versuchsplan geändert.

Während ich selbst ca. 20 m abwärts der Au Aufstellung nahm, wo der Wasserstand niedrig war und eventuelle Fische daher verhältnismässig leicht zu beobachten waren, wurden 50 Regenbogenforellen von 10—15 cm durch einen im voraus angebrachten und festgebundenen Trichter in die Turbine geschüttet, die ohne Wasserzufuhr lief (abgesehen von dem wenigen Wasser, das durch die undichten Schleusenschützen kam), nur von dem Hilfsmotor getrieben; mit einigen Eimern Wasser wurde nachgespült. Nach einem Augenblick wurde das Wasser bei der Turbine unklar und milchig, und mit dem Strom herunter kamen zerquetschte und breiige Fischstücke geflossen. Die Fische schienen in dem Masse zerrissen, dass auch kein centimeterlanges Stück heil geblieben war, und man kann mit Sicherheit annehmen, dass keiner der 50 Fische lebend durch die Turbine kam.

Inzwischen wurde es klar, dass der Versuch verkehrt angestellt worden war, indem nämlich der Umstand, dass die Turbine so gut wie trocken lief, bewirkte, dass die Fische, die hinabgeschüttet wurden, nicht mit normaler Geschwindigkeit hindurch gespült wurden, sondern allzu langsam hindurch gingen.

Die Turbinenschützen wurden daher hochgezogen, sodass die Turbine normal lief. Der Wasserstand im Hinterwasser stieg infolgedessen und die Beobachtung eventueller Fische wurde schwieriger, sowohl weil das Wasser höher stand, als auch weil der Strom viel stärker ging als vorher. 50 Regenbogenforellen von 15—20 cm wurden durch den Trichter geschüttet und mit einigen Eimern Wasser nachgespült. Auch dieses Mal kamen viele Fischstücke mit (lose Köpfe, Finnen, Eingeweide), aber es

wurden doch auch drei Fische aufgenommen, die noch lebten, aber freilich alle tödliche Schläge über das Schwanzstück bekommen hatten; das grösste unbeschädigte Stück, das wir fanden (von der Schnauzenspitze zur Schlagstelle am Schwanz gemessen), war 10 cm lang. Andere lebende Fische wurden nicht beobachtet; sind unbeschädigte Fische da gewesen, haben sie sich leicht der Aufmerksamkeit entziehen können, aber es scheint nicht wahrscheinlich, dass auch nur einer unbeschädigt davon gekommen ist. Die Turbine stand im voraus im Ruf, ein »Fleischhacker« zu sein, und von verschiedenen Seiten wurde erzählt, dass man oft Aale gesehen hätte, die durch die Turbine gegangen wären und mit Schlagmerkmalen in 8—10 cm Abstand im Hinterwasser lägen. Es ist danach am wahrscheinlichsten, dass keine der 50 Forellen lebensfähig durch die Turbine gekommen ist.

Nach dem Vorliegenden muss man annehmen, dass auch für Forellen von 10 cm keine grossen Aussichten sein würden, unbeschädigt durch die Turbine zu kommen. Sie ist daher als äusserst schädlich für die abwandernden jungen Forellen anzusehen, sofern diese nicht aussen herum mit dem Freiwasser passieren; und Freiwasser wird hier glücklicherweise fast jede Nacht gegeben.

Die bei diesem (sowie bei dem unten erwähnten) Versuch benutzten Regenbogenforellen wurden in Kübeln mit Sauerstoffbehälter auf einem Fuhrwerk aus der Teichwirtschaft von Hulkjær Mühle mitgebracht.

3. **Gjørklint Mühle** (Versuch vom 28/IX 1931).

Hier liegen zwei Turbinen, deren eine, eine Mahler-Turbine von 5 PS, die zur Herstellung von Elektrizität für den lokalen Verbrauch gebraucht wird, nicht mit für den Versuch benutzt wurde. Die andere ist eine Mahler-Turbine von 25 PS mit einer Fallhöhe von ca. 1,5 m. Die grosse Turbine, die 70 Umdrehungen in der Minute macht, liegt wagerecht auf dem Boden einer Turbinenkammer, unter dem ein Saugrohr mit einem Durchmesser von ca. 1,2 m senkrecht nach unten geht.

Nachdem der Wasserstand im Hinterwasser dadurch gesenkt worden war, dass zuerst eine Zeit lang Freiwasser gegeben wurde, wodurch das Wasser im Mühlenteiche sank, und danach die Schützen sowohl für das Freiwasser wie für das Turbinenwasser eingesetzt worden waren, ging mein Gehülfe mit der Reuse ins Wasser und es gelang ihm, die Reuse fest an das Saugrohr zu binden. Dies Saugrohr war von zwei Seiten aus zugänglich und hatte nach unten zu eine schwache kragenartige Erweiterung, die das Festbinden erleichterte; aber auch hier war kein Platz, um hinter das Saugrohr kommen zu können; die Reusenkante musste daher mit

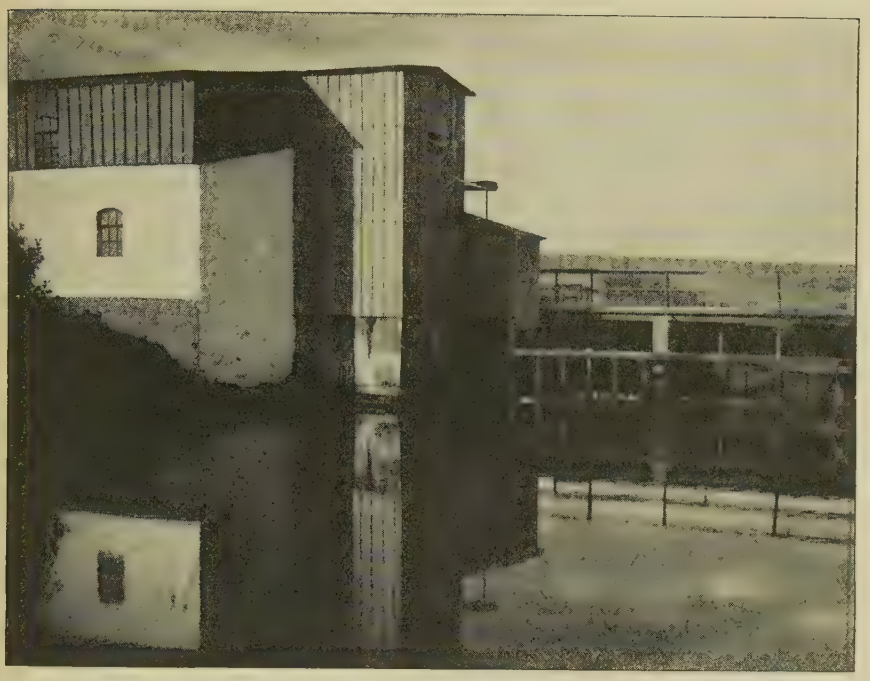

Fig. 3. Gjørklint Mühle. Die kleine Turbine ist unter dem niedrigen Haus mit schrägem Dach, während die zum Versuch benutzte Turbine in der cementierten Kammer unter dem hohen mit Brettern verschalten Gebäude liegt.

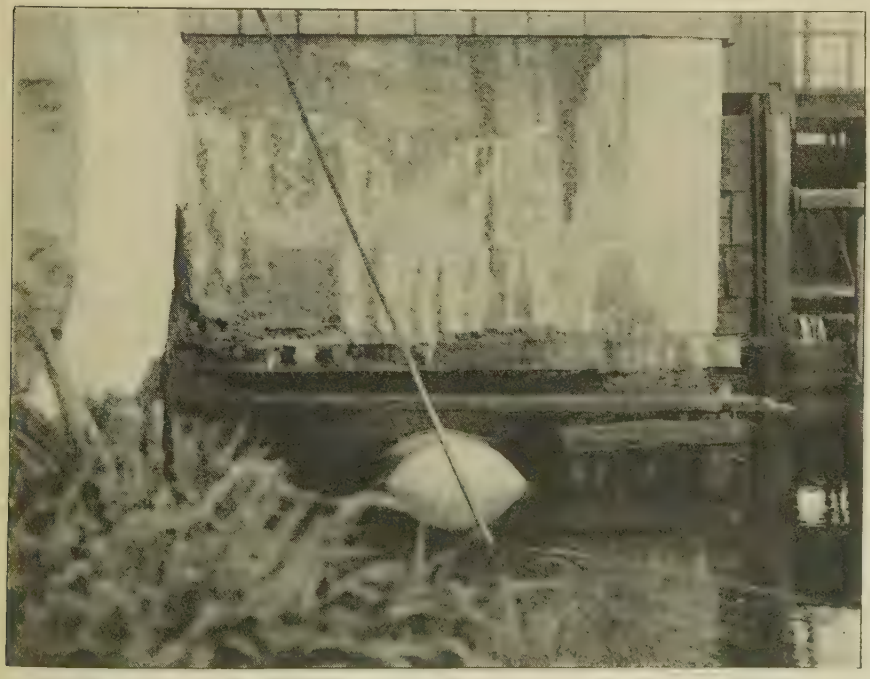

Fig. 4. Gjørklint Mühle. Die Reuse ist angebunden an das Saugrohr der Turbine, das eben unter der Turbinenkammer sichtbar ist. Der hintere Teil der Reuse ist an der schrägen Stange festgemacht.

einer Stange gehoben werden, um auf die Rückseite des Rohres geführt zu werden. Darauf wurde der Trichter mit seinem untersten Ende zwischen zwei Leitschaufeln angebracht und diese Lage durch Festbinden gesichert. Da die Reuse am Platze blieb, auch nachdem die Turbinenschützen hochgezogen worden waren, konnte der Versuch beginnen.

Zunächst wurde der Rest (51 Stück) der mitgebrachten Regenbogenforellen von der Grösse 10—15 cm in den Trichter geschüttet und dann nachgespült. Da es sich zeigte, dass die Reuse immer noch fest sass und es am besten schien, den Aufenthalt des Gehilfen im kalten Wasser nicht öfter als nötig zu wiederholen, wurde auch der Rest der Regenbogenforellen von der Grösse 15—20 cm (51 Stück) in den Trichter geschüttet und dann wieder nachgespült. Nachdem die Fische darauf in das Hinterende der Reuse geschüttet worden waren, wurde diese abgebunden, was so gut glückte, dass kein Fisch vorn entwich. Sie wurde an Land gebracht und die Fische gezählt. Es waren im ganzen 102, also alle verwendeten, und alle waren vollständig unbeschädigt.

Diese Turbine muss also als vollkommen unschädlich für die jungen Forellen angesehen werden.

Wie gross die Zahl der in Dänemark in Betrieb befindlichen Turbinen ist, hat leider nicht festgestellt werden können. Aber es scheint, dass die Mahler-Turbine der gebräuchlichste Typ ist, und von diesem sind in Dänemark 379 verkauft worden; davon sind 368, wie man annimmt, noch in Betrieb. Demnach liegt wahrscheinlich die Gesamtzahl der dänischen Turbinen zwischen 400 und 600, wohl am ehesten in der Nähe der ersten Zahl. Die Kraft dieser 379 Mahler-Turbinen liegt zwischen 1 und 1500 PS und verteilt sich folgendermassen: — Unter 5 PS: 21; 5—9 PS: 63; 10—14 PS: 85; 15—49 PS: 178; 50 PS und darüber: 32. Man kann hieraus schliessen, dass weitaus die meisten so gross sind, dass sie, nach den gemachten Versuchen zu urteilen, für die jungen Salmoniden unschädlich sind. Es bleiben aber immer noch einige zurück, die schädlich wirken können; ob sie es wirklich tun, wird in wesentlichem Grad von den lokalen Verhältnissen abhängen: ob der Wasserlauf ein Salmonidenwasser ist, ob häufig Freiwasser gegeben wird usw.

Die 1930 und 1931 untersuchten sechs Turbinen waren alle Reaktionsturbinen mit Zufluss von aussen (Francis-Turbinen). Fünf waren nach dem System Mahler von Møller & Jochumsens Maschinenfabrik in Horsens, während die sechste von der Aktiengesellschaft Frichs Fabriken, Aarhus, kam.

Die Mahler-Turbinen[1]) haben Spaltendruckregulierung (Fig. 5), das Laufrad ist in zwei Abteilungen geteilt; durch die obere läuft das Wasser beinahe parallel dem Radius, durch die untere parallel der Achse. Die

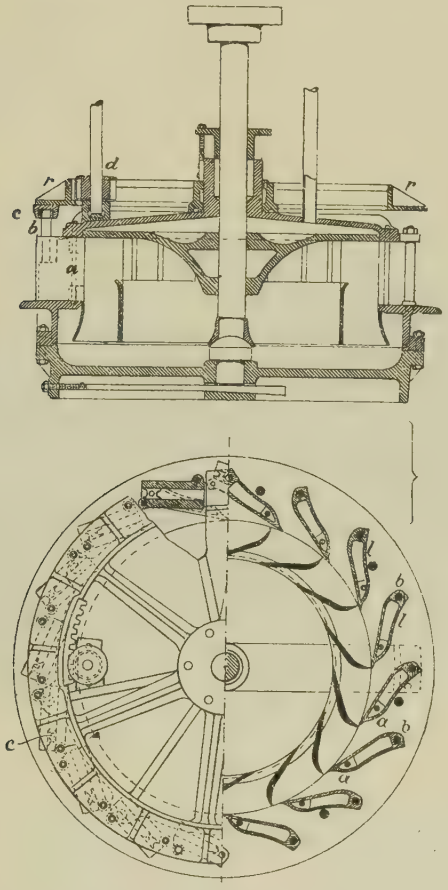

Fig. 5. Mahler-Turbine, schematische Darstellung. Nach S. C. Borch. Die Leitschaufeln *l* sind drehbar um die Zapfen *a* und tragen ausserdem selbst die Zapfen *b*, die in die Gleitklotzen *c* hinein passen. Diese wieder greifen hinein in schräge Rillen auf der Unterseite des Regulierungsringes *r*. Dieser Ring ist drehbar mittels eines Zahnbogens und Getriebes *d* und kann dadurch alle Leitschaufeln gleichzeitig einstellen.

Frichs-Turbinen[1]) bilden ebenfalls ein Zwischending zwischen Radial- und Axial-Turbine, insofern als die Schaufeln des Laufrades so gekrümmt

[1]) S. C. Borch: Forelæsninger over Maskinlære. I, Text und Zeichnungen 4. Ausgabe, Kopenhagen 1905.

sind, dass das Wasser, das von aussen hinein kommt, sich auch etwas parallel der Achse bewegt und das Rad in schräg abwärts gehender Richtung verlässt. Aber was diese Turbinen wahrscheinlich am meisten von den oben erwähnten in ihrer Wirkung auf die Fische unterscheidet, ist der Zuleitungsapparat (Fig. 7). Er besteht aus einem ringförmigen Schirm, der aussen um den eigentlichen Leitapparat herum liegt und für jeden Leitschaufelkanal ein Loch hat; auf der einen Hälfte des Umkreises sind die Leitschaufeln nach oben gekrümmt, sodass die äusseren Mündungen ein Stück gehoben sind, auf der andern Hälfte gehen sie

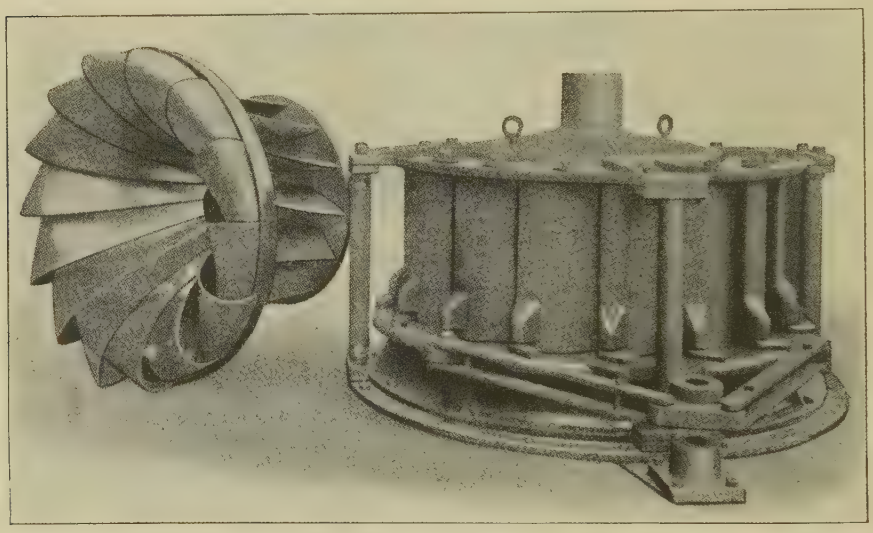

Fig. 6. Mahler-Turbine. Laufrad für Schnell-Lauf. Nach dem Katalog der Fabrik.

gerade durch; dieser Anordnung entsprechen die Öffnungen des Schirmes, indem sie auf der einen Hälfte höher liegen als auf der andern. Wenn man den Schirm dreht, kann man alle Leitschaufelkanäle schliessen oder einige oder alle öffnen.

Die untersuchte Frichs-Turbine hatte eine geradezu verheerende Wirkung auf die Fische. Sie ist 1905 geliefert und es sind seiner Zeit eine recht grosse Anzahl dieses Typs von 10, 20 und 30 PS für gewöhnlichen Mühlengebrauch hergestellt und verkauft worden. Jetzt bauen Frichs Fabriken indessen keine Turbinen mehr selbst, sondern liefern sie von »Verkstaden«, Kristinehamn, Schweden; von diesen schwedischen Turbinen haben sie an dänische Unternehmen geliefert: 3 von 15—50 PS und 8 von über 50 PS, darunter 3 von je 1800 PS an die Gudenaa Zentrale. Die schwedischen Turbinen sind nicht zum Gegenstand von Versuchen der hier geschilderten Art gemacht.

Die Mahler-Turbinen scheinen, wie erwähnt, bei uns die gebräuchlichsten zu sein. Was die fünf untersuchten Mahler-Turbinen betrifft, so scheint mit ihrer wachsenden Grösse die schädliche Wirkung auf die Fische abzunehmen, was an und für sich nur natürlich ist. Indessen können ausser Konstruktion und Grösse der Turbinen auch noch andere Umstände sich geltend machen, so z. B. die Rotationsgeschwindigkeit während des Versuches und der grössere oder geringere Wasserdruck,

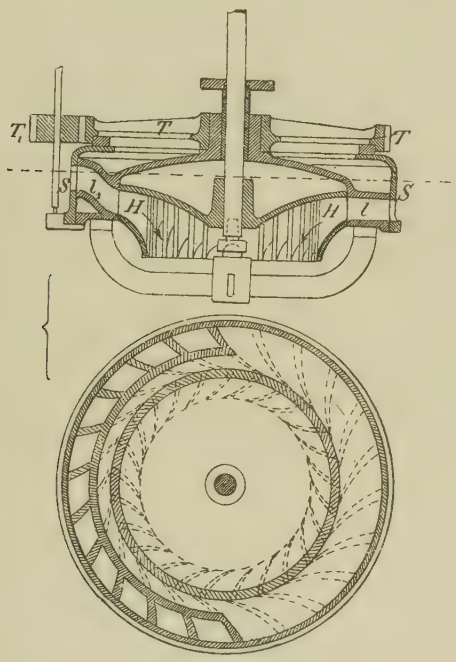

Fig. 7. Frichs-Turbine, schematische Darstellung. Nach S. C. Borch. H — Schaufeln des Laufrades, S — ringförmiger Schirm, der um den Leitapparat herum liegt, l — Öffnung zwischen den Leitschaufeln, die geradeaus gehen, l_1 — Öffnung zwischen den Leitschaufeln, die gekrümmt sind, T und T_1 — Zahnrad und Getriebe zur Drehung des Schirmes S.

der die Fische schneller oder langsamer durch die Turbine treibt; ausserdem natürlich noch der Unterschied in der Grösse der Fische. Aber alles deutet doch darauf hin, dass die Mahler-Turbinen von mehr als ca. 15 PS im allgemeinen für die abwärts wandernden jungen Forellen unschädlich sind, insoweit als die Fische durch die Turbine passieren können, ohne Schaden zu leiden. Eine ganz andere Frage ist es aber, ob die jungen Forellen die Turbine freiwillig aufsuchen oder ob sie, wenn kein Freiwasser gegeben wird, dem sie folgen können, es nicht vorziehen,

oberhalb der Turbine stehen zu bleiben (also Bachforellen zu werden). Wie wichtig es ist, diese Frage zu klären, hat auch Dr. E. Frischholz, München, mir gegenüber schriftlich hervorgehoben.

Nach dem bisher Vorliegenden muss es auf jeden Fall unzweckmässig scheinen, den jungen Forellen bei ihrer Abwärtswanderung Hindernisse in der Form von dichten Gittern in den Weg zu legen, wenn es sich um Turbinen des Mahler Typs von mehr als ca. 15 PS in Verbindung mit einer Fallhöhe von 1—2 m handelt. Dagegen würde ein dichtes Gitter vor Frichs-Turbinen von den Dimensionen der untersuchten am Platze sein. Ausser jungen Lachsen und Forellen kommen in den meisten Fällen nur Aale für Abwanderung in Frage, doch in den meisten eigentlichen Forellenwassern wird der Aalzug hauptsächlich im Herbst vor sich gehen; in Wasserläufen mit Seen im Flussgebiet (besonders Seen, die nicht stark durchströmt werden) kommt auch häufig ein bedeutsamer Frühjahrszug von Blankaalen vor, also gleichzeitig mit dem Forellenzug. Die Aale wandern fast nur während der Nacht, während man noch nicht weiss, ob die Forellen ohne Rücksicht auf die Tageszeiten ziehen. Da man, jedenfalls vorläufig, damit rechnen muss, dass die Blankaale durchweg die Turbinen nicht unbeschädigt passieren können, müsste man also in jedem Fall einzeln entscheiden, ob ein Gitter mit dichten Stäben vor der Turbine voraussichtlich Nutzen bringt, bedeutungslos ist oder Schaden tut, und ferner, zu welcher Jahreszeit es eventuell zu setzen ist.

Bis jetzt fehlen noch viele Beobachtungen, bevor allgemeingültige Regeln für die Schädlichkeit der Turbinen für die Fische gegeben werden können. So wäre es z. B. wertvoll, wenn die Bedeutung der Umdrehungsgeschwindigkeit festgestellt werden könnte. Seit 1910 geht die Tendenz in der Richtung der schnell-laufenden Turbinen, wenn auch die langsamen immer noch geliefert werden. Die Kraftleistung allein ist an und für sich kein Ausdruck für die Dimensionen der Turbine, da zur gleichen Kraftleistung Turbinen von grösserem Durchmesser gebraucht werden, wenn die Fallhöhe gering ist, als wenn sie gross ist.

Man hat Versuche gemacht, die verschiedenen mitbestimmenden Faktoren in eine Formel zu bringen, die zur Beurteilung einer Turbine angewandt werden könnte. L. Kreitmann (Ministère de l'Agriculture, Direction générale des Eaux et Forêts. Annales, fascicule 58. Paris, 1930) hat es versucht, eine solche Formel aufzustellen zur Berechnung der Verhältnisse zwischen der Länge des Fisches (l) und seiner Aussicht (p), unbeschädigt durch eine Turbine mit inwendigem Zufluss (Fourneyron-Turbine) zu kommen. Bezeichnet v die Geschwindigkeit des Laufrades, v_0 die Einsaugegeschwindigkeit des Wassers (und des

mitgerissenen Fisches), n die Anzahl der Schaufeln auf dem Laufrad, n_1 die Anzahl der Leitschaufeln, r den Radius des Laufrades, e den Abstand zwischen Laufrad und Leitrad und i den Winkel der Leitschaufeln zum Leitrad, findet er:

$$l = \frac{2\pi r v_0}{v}\left(\frac{1}{n}+\frac{1}{n_1}\right)\sqrt{\frac{1 \div p}{2}}+\frac{e}{\cos i}.$$

Eine Nachprüfung dieser Formel in der Praxis hat jedoch noch nicht stattgefunden und ihr Wert ist daher noch ungewiss.

Kreitmann hat durch Versuche nachgewiesen, dass die verschiedenen Versuchsfische, z. B. Forellen, plötzliche Druckveränderungen von 20 Atmosphären ohne geringsten Schaden ertrugen. Dieser Nachweis stimmt mit der Beobachtung, dass Fische, die während des Durchgangs durch die Turbine nicht verwundet worden sind, ganz normal befunden werden, also unbeeinflusst durch die erlittene Druckveränderung.

The Spawning Mark on Sea Trout Scales: a Reply to Dr. Mottram's Criticisms.

By

G. Herbert Nall.

My attention has been drawn to an article contributed to the Journal du Conseil of December 1931 by Dr. J. C. Mottram, entitled "The Spawning Mark on Sea Trout Scales". Most of the points raised by Dr. Mottram are dealt with in a paper entitled "Difficulties of Age Determination and Length Calculation from the Scales of Sea Trout", written by Mr. W. J. M. Menzies and myself and issued by the Fishery Board for Scotland this year[1]).

Dr. Mottram describes, with sketches, an inward bend of the ridges at the shoulder of sea trout scales, which (p. 436) he regards as evidence that the fish has spawned. He attacks me for neglecting, as he asserts, to notice this evidence, and on the strength of this and similar statements, challenges the general accuracy of my "deductions with regard to the life of the sea trout" in my recent book[2]).

It is quite incorrect to say that I have failed to notice this type of formation at the shoulder. On the contrary, I have studied it with care. But, in common with my fellow workers of the Fishery Board for Scotland, I differ from Dr. Mottram, because I do not hold that this inward bend is an infallible proof of erosion and spawning. For example, it is found not infrequently on the first sea winter of salmon, where without question it cannot be a spawning mark. Dr. Mottram himself (p. 437, top) admits that in maiden fish "a curling in ....of the first two or three summer ridges may occur following the winter check...". True, he

[1]) Fisheries, Scotland, Salmon Fish., 1931, No. 5. Edinbugh, 1932.

[2]) The life of the Sea Trout, G. Herbert Nall, Seeley, Service & Co., London, 1930.

adds, "but with an absence of any erosion of the winter ridges". But since on resumption of growth the eroded portion of the scale, save where erosion has been very severe, is completely filled by new growth, the only evidence for previous erosion is as a rule the local distortion in the new ridges. Dr. MOTTRAM might reply, "No; the old ridges have been cut short by the erosion and the new ridges curl round their shortened ends". Unfortunately, quite apart from erosion, the ridges forming a winter band not infrequently fall a little short of the neighbouring ridges. This test, therefore, is of little value. In fact, Dr. MOTTRAM's position seems to be, "If there has been previous erosion, then this inward bend of the new ridges at the shoulder is a spawning mark; if there has not been previous erosion, then a precisely similar formation is not a spawning mark". But this is not very helpful.

If the inward bend is slight and confined to the top part of the shoulder, in other words if it is doubtful whether it is a spawning mark or not, my practice is to study a large number of scales from the individual and base my conclusion on the evidence thus obtained. It is absurd to suppose that one can decide such a point (as Dr. MOTTRAM claims to do) by a glance at the photograph of a single scale.

Dr. MOTTRAM's so-called tracings in Fig. 3 are very misleading, as any reader will admit, who refers to the plates in my "Life of the Sea Trout". In the plate corresponding to his Fig. 3 (a), a definite spawning mark on the second post-migration winter shows clearly at both sides of the scale. The first post-migration winter on the other hand does not bear anything that an experienced scale reader would for a moment regard as a spawning mark, nor does examination of the rest of the batch of scales from this fish in any way confirm Dr. MOTTRAM's hasty and ill-advised pronouncement.

His Fig. 3 (b) also is misleading. I admit, however, that in the corresponding plate in my book there does seem to be at the shoulder a weak spawning mark on the third post-migration winter. Still more suspicious and suggestive of spawning is the slight degeneration of the ridges, visible at the top of the scale and on the right side, which Dr. MOTTRAM does not notice. But such degeneration of the ridges is not always associated with spawning. It appears, for example, on the second sea winter in the scale of a "large spring" salmon, figured in plate 3, facing page 12, of Mr. MENZIES' book on the salmon. In the case of my fish, a careful examination of the whole batch of scales from the individual, over fifty in number, established that the mark was not a spawning mark. I may add that this fish came from the Nilort and in Nilort sea trout the spawning mark is almost invariably very clear.

Dr. MOTTRAM's Fig. 3 (c) can hardly be described as a "tracing" of part of my plate 37, but the point is unimportant. I have a little over 60 sets from this Swedish river, but I have expressly stated in my book that I have no personal knowledge of it, that the scales of its sea trout are as a rule difficult to read, and that I am doubtful about many. In the case of this particular fish, after examining a number of its scales and obtaining the opinions of my fellow workers, I thought it probable, but not certain, that the second post-migration winter bore a spawning mark. If Dr. MOTTRAM had any acquaintance with the sea trout scales of this Swedish river, he would realise that my doubt was justified.

I have no wish whatever to shirk responsibility for my descriptions of these scales; but, as it happens, the three readings, which Dr. MOTTRAM has picked out for criticism, were the agreed readings of Mr. MENZIES, Mr. MACFARLANE and myself, and were based on the careful examination of a large number of scales from each fish.

I certainly do hold that in the character and the strength of the spawning mark sea trout more closely resemble salmon than fresh-water trout, just as, after the migration stage, sea trout are more akin to salmon in habit. This point is dealt with fully in the "Difficulties..." paper, which I mentioned above. In order to emphasise the probability of error, Dr. MOTTRAM seems to suggest that very weak erosion at spawning time and very weak spawning marks are quite common on sea trout scales. In fact, in Scotland and most other parts of Britain, in Ireland and in Norway, strong or medium erosion is the rule and weak erosion the exception.

Thus in the Howmore river of South Uist, a district where erosion is far lighter on the whole than in most west coast rivers of Scotland, since the trout run up rather late, Mr. MENZIES, Mr. MACFARLANE and myself found that, out of 227 kelt sea trout and 75 clean S.M. sea trout, 20 per cent. had erosion affecting only the first third of the margin, reckoned from shoulder to apex ("weak"), 44 per cent. had erosion extending from the shoulder well over the second third of the margin ("medium"), and 26 per cent. had erosion extending from the shoulder almost up to, or right up to, the apex ("strong"). In very few cases was it confined to the shoulder proper, as in Dr. MOTTRAM's Fig. 2 (c).

In most districts, it is true, one does find among the kelts a few examples where the erosion has been so weak that it is difficult to detect and a few doubtful spawning marks. A search, however, through the whole batch of scales from the individual usually enables one to reach a correct decision. If the point still remains doubtful, it is my practice to omit the fish from my list. I have frequently mentioned this element

of uncertainty in my Fishery Board papers and have referred to it in my book, but I am convinced that the possible margin of error in my published tables, due to this uncertainty, is so small as to be of little account.

The possibility that an earlier spawning mark may have been removed by erosion in the following winter (mentioned by Dr. MOTTRAM on p. 437) is discussed in the "Difficulties..." paper, in several other Fishery Board papers and in my book. Such cases are very rare and the percentage of error in my tables due to this cause is quite negligible.

On p. 434 Dr. MOTTRAM asserts that he "has examined the sex organs of several hundred sea trout older than herling (whitling).... and has not found a fish which was not going to spawn in the following winter". This is a startling statement, which makes one wonder whether he kept a written record of his observations or is trusting to memory. It flatly contradicts the experience of my fellow workers of the Fishery Board for Scotland and myself, to say nothing of Scandinavian investigators. In late autumn, in Scotland and Ireland, I have found a fair percentage of sea trout older than whitling with non-ripening sex organs (internal examination). Further there is the evidence obtained during winter marking operations. In most cases it is easy to separate at this season the ripe and the spawned fish from the non-ripening fish. I can only suggest that if Dr. MOTTRAM has in fact examined internally in late autumn *several hundred* sea trout, a year or more older than whitling, from rivers and lakes in the countries which he mentions, and did not find a single non-ripening specimen among them, he has been singularly unfortunate in his samples, which cannot have been representative of the general sea trout stock in these countries.

If Dr. MOTTRAM really believes that practically all sea trout begin their spawning career not later than the second post-migration winter, I suggest that he should study some of the papers on sea trout issued by the Fishery Board for Scotland. He would learn that thousands of clean maiden sea trout, in high condition, with undeveloped sex organs and uneroded scales, run up the Tweed to the Till between November and March. The bulk of these are in their second post-migration winter, a few in their third. Such fish could not spawn before their third or fourth post-migration winter. Similar fish, but smaller for their age, are found in the Tay, Spey and other large east coast rivers in spring, and they form the bulk of the big catches, mounting to thousands, made by the Solway nets in the early months of the year.

Dr. MOTTRAM's concluding sentence, "It follows that ....open to doubt" is quite unjustified. The two readings which he challenges are

correct; my hesitation about the third reading I hold to be wise caution. There is not, therefore, as he suggests, a ten per cent. error in my readings. At most he has re-stated what in my published papers and in my book I had already explained to be the case, namely that absolute accuracy is unattainable in dealing with sea trout scales and that there must be a small percentage of error, especially in the tables giving the Age at Maturity in samples from various districts. But the percentage of error is so slight, when a man works from large collections and carefully tests his results by the devices familiar to experts, that it does not affect the validity of his general deductions.

A similar percentage of error is unavoidable in reading the scales of salmon which bear one or more previous spawning marks.

I consider sea trout scales from many parts of Scotland as reliable for age determination and growth measurements as salmon scales; in some districts they are slightly less reliable. I have in mind, of course, the results obtained by trained workers, not those of amateurs.

Correspondence.

The Spawning Mark on Sea Trout Scales.

Edinburgh, 10th February 1932.

Sir,

I feel that there are one or two aspects of Dr. MOTTRAM's article on the spawning mark on sea trout scales in your last issue which I cannot allow to pass without comment.

Whatever be the merits of Dr. MOTTRAM's criticisms, and I for one

Fig. 1.

am of the opinion that after studying more material from a greater number of districts he would probably modify some of his statements, I do not consider that he is doing Mr. NALL justice in the alleged reproductions of portions of the illustrations from his book.

For instance in Figure 3a, an alleged tracing of part of Plate 26 in Mr. NALL's book, the essential portions are so drawn, or misdrawn, as

not to represent accurately the actual scale photograph. I attach hereto (Figure I) an enlarged photograph of the essential portion of the scale showing Dr. MOTTRAM's X and Y to differ not only considerably from his diagram but also from each other as chalk from cheese. At his "Y"

Fig. II.

the erosion has quite clearly and definitely cut right across six scale ridges and two further scale ridges have been added growing at an angle of approximately 45° to the older formation. At "X" there is merely one incurved ridge such as one commonly sees on *clean* whitling (herling) scales during the winter months and which is certainly indicative of neither erosion nor a spawning mark. This single ridge I may also say at "X" appears to curve more in the diagram than in the actual photograph. At "Y" the eroded ridges run in to the scar; at "X" they do not,

since there is no scar. If the new scale growth at "Y" be cut off the appearance is that of definite erosion; this is not so at "X" where the ridges within the incurved ridge have obviously ceased to grow when shorter than the neighbouring ridges and their ends have *not* been removed by erosion.

In his Figure 3b, Dr. MOTTRAM again does not represent the situation in the same manner as the photograph, of which also I attach an enlargement (Figure II). Here there is actually a good deal more incurving of

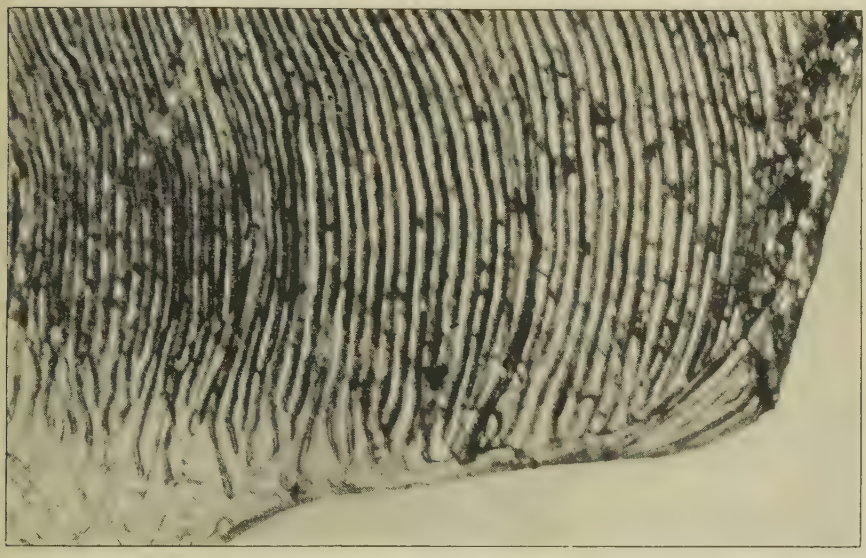

Fig. III.

the one particular ridge in dispute than is the case in the former figure: this is one of the cases in which I suggest Dr. MOTTRAM's lack of experience leads him astray. If he will trace the particular ridge which he regards as the spawning mark up the scale he will see that it comes down from a slow-growth band. Were he acquainted with the Ailort sea trout he would know that this slow-growth band is formed during the winter months and at its base there may be incurving of the ridges just as there may be, and very often is, incurving of salmon scale ridges at the same period of growth. Were he also further acquainted with the Ailort sea trout he would know that a large proportion of them run early in the year and that erosion of the scales of such fish must necessarily be, and is always, considerable before the spawning period is reached, while after growth again commences the spawning mark on scales from this particular district is always particularly clear and distinct. In fact the

Ailort sea trout scales may be regarded as quite the easiest and most definite of all we have to read; in their case comparatively little confirmatory evidence was required when the original study of scales from this district was made: it is far otherwise in districts where the run of fish may occur late in the year. The same remarks as for Figure I are applicable to the ridges before the alleged spawning mark. In this case these ridges are also slightly incurving as indeed are those at the previous winter which Dr. MOTTRAM does not consider to be a spawning mark.

With regard to Figure 3c I have the same comments to make and an enlargement (Figure III) to show as in the previous two cases. Here I would also add that the scales of these Swedish sea trout fed in the brackish waters of the Baltic partake much more of the nature of brown trout scales than do the scales of sea trout which feed in the more salt North Sea and Atlantic waters. In my view, therefore, owing to the lack of confirmatory evidence such as we have in the case of Scottish and other scales, Mr. NALL was more than justified in not being definite in this reading and only suggesting that in his judgment this mark *may* be a spawning mark.

Yours faithfully,

W. J. M. MENZIES.

Editorial Note.

We welcome the issue by the Deutsche Seewarte of a new bi-monthly journal, "Der Seewart", dealing principally with matters relating to navigation and seamanship. In a foreword to the first number Admiral DOMINIK explains that its publication fulfils the long-felt desire to extend the scope of the organ "Der Pilote", publication of which is now discontinued. "Der Seewart", besides including the navigational announcements formerly made in "Der Pilote", will contain scientific and technical articles of interest to seamen.

In addition to official information, the first number contains articles by Professor SCHULZ (The development of shipping in north-polar regions), Dr. E. SCHREIBER (The applicability of infra-red radiation in fog and weather of low visibility), and A. E. SCHMIDT (Calculation and preparation of a trimming plan on board).

Reviews.

E. Palmén. Untersuchungen über die Strömungen in den Finnland umgebenden Meeren. — Soc. Scient. Fennica. Comm. Phys.-Math. V, 12. Helsingfors u. Berlin, 1930.

Diese Untersuchungen, als deren Vorläufer die Arbeiten des Verf. in diesen Blättern (I, Nr. 4, 1926) und in den »Rapports et Procès-Verbaux« (LXIV, 1930) anzusehen sind, beziehen sich namentlich auf den Bottnischen und den Finnischen Meerbusen, zwei Meeresteile, die, trotz der Einfachheit ihrer Umrandung, der Forschung besonders durch wechselvolle meteorologische Verhältnisse Schwierigkeiten bereiten. Wenn trotzdem die vorliegende Arbeit wertvolle Ergebnisse zu Tage fördert, so ist dies nur dadurch möglich, dass sie sich auf ein sehr reiches Material stützt, nämlich 5 Jahrgänge mehrfach am Tage gemachter Beobachtungen von 15 finnischen und schwedischen Feuerschiffen und eines estnischen, und dass überdies der Verf. besondere Wege zur Auswertung einschlägt.

Unter den vier ungleichen Teilen der Arbeit entfällt das Hauptgewicht auf die mittleren beiden, die, wie auch der kurze letzte, Sonderfragen gewidmet sind, während der erste einen allgemeinen Überblick über die mittleren Oberflächenströmungen gibt, wie sie durch vektorielle Mittelberechnung der Einzelbeobachtungen herauskommen. Es zeigt sich, dass beide Meerbusen von »antizyklonalen« Strömen (= *contra solem*) umkreist werden, die aber sehr schwach sind und im Mittel 9 cm/sec nicht erreichen; auch ist ihre Beständigkeit sehr gering und erreicht nur bei dem achten Teile von ihnen einen Betrag von mehr als 50 %; in Einzelfällen wurden dagegen Geschwindigkeiten von $^1/_2$ bis $^3/_4$ m/sec beobachtet, und deshalb erklärt sich die Kleinheit der mittleren Bewegung dadurch, dass die stärkeren Einzelströme sich zum grossen Teile gegenseitig aufheben. Die treibende Kraft ist in den Dichte-Unterschieden, nicht in den wechselnden Winden, zu erblicken.

Im zweiten Abschnitte vergleicht der Verf. die Strombeobachtungen mit der Ekman'schen Theorie. Die Schwierigkeit besteht hier darin, aus den Beobachtungen reine Triftströmungen auszusondern, und andere Ursachen als den Wind auszuscheiden. Die Untersuchung beschränkt sich daher auf das nordwestlich der Ålandsinseln gelegene Feuerschiff »Finngrundet«, da bei den anderen die Strömungen durch die Nähe der Küste zu sehr entstellt werden. Nach einer von H. U. Sverdrup angegebenen graphischen Methode erweisen sich in der Tat die Küsteneinflüsse für Finngrundet als geringfügig, doch muss ein dauernder »charakteristischer Strom« nach S. bis SSO. eliminiert werden, um den reinen Triftstrom zu erhalten. Des letzteren Schnelligkeit ist proportional zur Windgeschwindig-

keit v (nicht zu $\sqrt{2}$, wie früher von anderer Seite berechnet wurde); dass dagegen der Winddruck, wie Verf. annimmt, ebenfalls proportional zu v, nicht zu v^2 sei, darf bezweifelt werden. Bei »Finngrundet« erzeugt ein Wind von 1 m/sec einen Strom von 1,23 cm/sec; das stimmt gut zu einem früher vom Unterzeichneten aus anderen Beobachtungen berechneten Werte, der für die geographische Breite von Finngrundet = 1,35 cm/sec sein würde. Die Ablenkung betrug 39° (rechts) bei einem Winde von 2—3 Bft. und nahm bei stärkerem Winde ab, was durchaus im Sinne der Ekman'schen Theorie liegt. Nicht aber lassen sich mit dieser die in 20 m Tiefe gemessenen Ströme vereinigen; auch dann nicht, wenn man die neueren von Ekman und Fjeldstad vorgenommenen Verfeinerungen der Theorie berücksichtigt. Die Tiefenströme sind daher nicht als unmittelbar vom Winde erzeugt anzusehen, doch liegen die Verhältnisse bei »Finngrundet« zu verwickelt, um Näheres über sie auszusagen.

In dieser Beziehung bietet der einfacher gestaltete Finnische Meerbusen mehr Aussicht auf Erfolg, und Verf. behandelt (Abschnitt III) zunächst die auf einem Querschnitte, etwa auf der Länge von Helsingfors, gemachten Beobachtungen, aus denen er 45 Perioden auswählt, in denen entweder östliche oder westliche Winde je drei Tage lang herrschten, so dass auf stationäre Zustände zu rechnen ist: »E-Typ« und »W-Typ«. Durch Abtrieb oder Anstau entsteht dann zuerst ein Gefälle in der Längsrichtung des Meerbusens; viel auffallender aber sind die durch die ablenkende Kraft der Erdumdrehung hervorgerufenen Veränderungen in der Querrichtung, da die Sprungschicht zwischen dem oberflächlichen angesüssten Wasser und dem salzreichen und entgegengesetzt fliessenden Wasser der Tiefe sich schräg stellt. Sie liegt normaler Weise in der Mittelachse in 27 m Tiefe, im Norden (bei »Äransgrund«) aber beim »E-Typ« etwa 8 m tiefer, beim »W-Typ« etwa ebenso viel höher. Die Zahl der Bjerknes'schen Solenoide ist eine ausgesprochene Funktion der Windrichtung; zur Berechnung der Tiefenströme verwendet Verf. jedoch die Defant'schen Formeln; sie ergeben zwar nicht den Tiefenstrom selbst, sondern nur den Unterschied zwischen Tiefen- und Oberflächenstrom, und es erübrigt, den letzteren zu ermitteln, um die absoluten Ströme kennen zu lernen. Da nun die Erdumdrehung den Wasserspiegel schräg stellt, so verwertet Verf. umgekehrt die von den Pegeln aufgezeichneten Wasserstände, um aus ihnen den Oberflächenstrom abzuleiten; das Rechnungsergebnis entspricht in der Tat den Beobachtungen. Eine besonders auffällige Wirkung des Umstandes, dass die Tiefenströme dem Winde entgegen laufen, besteht darin, dass der Salzgehalt des Finnischen Meerbusens als Ganzes beim »E-Typ« zu-, beim »W-Typ« jedoch abnimmt! Von weiteren theoretischen und praktischen Einzelheiten sei hier abgesehen; nur auf die häufigen Temperatursprünge des Oberflächenwassers (Abschnitt IV) sei hingewiesen, die noch kürzlich von Mäe durch Aufquellen des Tiefenwassers infolge von Landwinden erklärt wurden. Verf. zeigt dagegen, dass küstenparallele Winde wegen der Erdrotation ebenso wirksam sind, und dass in einem Falle sogar ein schwach aufländiger Wind einen Temperaturfall von 5° C. zur Folge hatte. — Mehr anzuführen verbietet der Raum; doch mag man aus dem Gesagten entnehmen, dass nicht nur die Ergebnisse, sondern auch besonders die Methoden des Verfassers Beachtung verdienen. H. Thorade.

F. Hopfner. Die Gezeiten der Meere. Handbuch der Experimentalphysik, Geophysik, 2. Teil. Leipzig, 1931.

Literature on the tides may be divided into two classes according as the primary object is the advance of knowledge itself or the exposition of knowledge previously gained. To the first of these classes belong the numerous papers published in scientific periodicals, and certain historic treatises such as those of Newton, Laplace, Airy and Ferrel.

To the second class belong:—

1. popular books such as those of Darwin, Wheeler, Fichot and Marmer, intended for the general reader;
2. manuals, such as those published by the Survey of India and the Coast and Geodetic Survey of the United States, intended for those engaged in technical work;
3. chapters in textbooks such as Krümmel's Ozeanographie and Johnstone's Oceanography, intended for the non-mathematical student;
4. textbooks such as those of Lévy and Bouasse and the chapter in Lamb's Hydrodynamics, intended for the mathematical student;
5. articles in encyclopaedias, consisting of summaries and condensed treatises.

Harris' Manual of Tides and Poincaré's Théorie des Marées belong to both classes.

The work under review belongs to the last division enumerated above and is certainly one of the best of the encyclopaedia articles. Though it has not the fullness of the mathematical treatises and textbooks, yet it is not too condensed to give a real insight into the subject. Though intended for the mathematical reader, it is probable that the non-mathematical reader will learn a great deal from its perusal. No important aspect of the subject seems to have been omitted and the references are very numerous.

Criticism can only be directed towards one or two statements of an historical nature. On p. 728 it is wrongly asserted that Laplace's work did not take into account the dynamical effects of the earth's rotation. On p. 748 it is asserted that the complete theory of free tides of a rotating rectangular sea of uniform depth had not been given, in spite of the fact that G. I. Taylor gave this theory in the paper from which Hopfner quotes much on the rectangular gulf. J. Proudman.

Otto Petterson. The Tidal Force. A Study in Geophysics. — Geografiska Annaler, 1930. Heft 4, pp. 262—322. Stockholm, 1931.

The title of this paper is somewhat of a misnomer, for as the author states explicitly at the outset, it deals not with the tide-producing forces as ordinarily understood, but with the vertical component of the tide-producing forces. In the study of tides this vertical component is ignored since its effect is merely to bring about a very small variation in the intensity of gravity, the tidal movement of the waters being due to the horizontal component of the tide-producing forces.

In this paper the veteran Swedish oceanographer deals with various oceanographic and meteorologic matters. Primarily, however, it is devoted to elaborating the thesis that the vertical component of the moon's tide-producing force "exercises a powerful influence on the inner movements in the intermediate layer of the sea and consequently on the whole of the oceanic circulation". From observations on the variation in salinity at different depths in Gullmarfjord, PETTERSSON finds evidence of the existence of internal waves with periods corresponding to various lunar periods. Internal or boundary waves in the sea are phenomena about which relatively little is known. They manifest themselves as vertical oscillations of the boundary surface between water strata possessing marked differences in temperature or salinity, and are frequently of large amplitude — measured in tens of metres. Especially difficult to understand is the periodicity that frequently is manifested by such waves.

PETTERSSON puts forward the hypothesis that internal waves of large amplitude and sharply-marked periodicity are brought about by changes in the intensity of the vertical component of the moon's tide-producing force. He shows that the mean daily value of the variation in the intensity of gravity at any place, due to this vertical component, is itself subject to variations with periods varying from half a month up to 1850 years. He finds further that the variations in salinity at Gullmarfjord have periods which accord with the periods determined from the variations of the vertical component of the tide-producing forces.

The formula for the vertical component of the moon's tide-producing force contains a term involving latitude, which shows that in latitude 35°16′, in both the northern and southern hemispheres, the value of this component is zero. Polewards from these latitudes the mean value of this component is in the direction of gravity, while equatorwards it acts in a direction opposite to gravity. Due to the fortnightly change in the moon's declination, the vertical component is subject to a fortnightly variation, which alternately increases and decreases the difference in the intensity of gravity in the two zones. This, according to PETTERSSON, affects the sea in that "twice a month a tendency arises for the streaming of water from the Polar regions towards the Equator, and the other way round during the intermediate periods".

PETTERSSON thus finds that "the driving power in the oceanic circulation, therefore, is primarily the vertical tidal force, which brings about a current of cold water along the floor of the sea from the Polar seas to the Equator. After that comes the influence of solar radiation on the uppermost layers of water in the sea and the transformation of the heat into kinetic energy through evaporation and the melting of ice... In the third place comes the influence of winds and the atmospheric pressure on the movements of the surface water." He notes, however, that oceanographers "would probably reverse this order... (and) ignore the cosmic influence that I have placed first".

As a further consequence of his hypothesis, PETTERSSON concludes that "when the vertical tidal force increases, the intensity of the circulation of water in the ocean is augmented at all levels and in all latitudes". This, according to the author, will be accompanied by changes in the system

of oceanic circulation, the more important of which are: (a) "that the melting of the ice in the Polar seas and the ice-drift from there is increased because the supply of warm water from the tropics northwards and southwards becomes stronger"; and (b) "that the great sea currents pendulate — that is to say, diverge to the right (or else to the left) — when an acceleration of their velocity occurs".

The variations in the vertical tidal force can be calculated from astronomical data, so that the dates when this force attains its periodic maximum values can be readily derived. PETTERSSON shows that such maxima occurred in September 1895 and again in September 1922. He then discusses the ice conditions in the Arctic and Antarctic oceans in the last decade of the nineteenth century, connecting these conditions with the increased value of the vertical tidal force.

In the introductory part of the paper, in which he summarizes the contents, PETTERSSON very scrupulously states that he "has come to occupy an isolated position among the hydrographical and meteorological students of the present day owing to the fact that he has found movements in the hydrosphere of the earth to have their ultimate cause in the variations in the force of gravity." There can be no question that most qualified students of the matter will disagree with PETTERSSON's thesis as developed in this paper, but at the same time will heartily indorse his statement that "the study of such internal movements in the sea ought to be an important task for the marine stations that have been established round the coasts of Europe". H. A. M.

J. W. Sandström. Der Golfstrom und das Wetter. Gerlands Beitr. z. Geophys. Band 32, Köppen-Bd. I. Leipzig, 1931.

The "Gulf Stream" of this paper is the warm current which traverses the North Atlantic and penetrates the Arctic Ocean through the northern North Sea. It is well known that this current has a great effect in ameliorating the winter climate of north-west Europe; this effect is partly direct but it is also partly indirect, through the modifications which it introduces into the general pressure distribution. Hence variations of the Gulf Stream from year to year should result in corresponding changes of weather. SANDSTRÖM describes a special case. In the summer of 1928 the Gulf Stream near Florida was 5° C. warmer than normal. In the following winter this mass of warm water lay south of Iceland and the Icelandic low pressure area increased greatly in intensity and also shifted towards the south-west, while the Siberian anticyclone advanced westward, giving an abnormally cold winter in north-west Europe. By the winter of 1929—30 on the other hand both the warm water and the Icelandic low had moved to the north-east of Iceland, giving a mild winter in Norway. The author considers that these relationships may form a basis for seasonal forecasting.

There is no doubt that variations in the strength of the Gulf Stream do influence the subsequent pressure distribution over the North Atlantic and western Europe, but this is by no means the only factor at work. Two others at least are probably still more powerful, namely, the state of

ice in the Arctic Ocean and the pre-existing general meteorological situation over the globe. Moreover all three, Gulf Stream, Arctic ice, meteorological situation, interact and the result is our very complex sequence of seasons. Thus, while the Gulf Stream was no doubt a part cause of the severe winter of 1928—29, it is not likely to have been the sole cause. C. E. P. B.

T. Braarud and **B. Føyn.** Beiträge zur Kenntnis des Stoffwechsels im Meere. Norske Vid.-Akad. i Oslo. 1. Matem.-Naturvid. Klasse 1930. No. 14. Oslo, 1931.

Sea water was filtered free from bacteria and the phosphate, nitrate-, nitrite- and ammonium-nitrogen determined chemically. To one portion an excess of nitrate and to the other an excess of phosphate were added; both were then seeded with a pure bacteria free culture of *Chlamydomonas*. From the increase in number of cells of this alga, the quantity of phosphate and nitrate respectively which had been assimilated during growth were calculated. It had been found that 2.98×10^{-12} gms. nitrate-nitrogen and 0.98×10^{-12} gms. phosphate as P_2O_5 were utilised in the production of each cell of *Chlamydomonas*. The technique was the same as that used by Schreiber. In the case of the three waters examined, the phosphate thus estimated agreed very closely with the chemical determination. The estimate of combined nitrogen by the biological and chemical methods did not agree so closely, but a parallel is shown.

Water from	$NO_3' + NO_2'$-Nitrogen mg per m^3	NH_4'-Nitrogen mg per m^3	NO_3', $+ NO_2'$ and NH_4' nitrogen	P_2O_5 mg per m^3	Nitrogen used by algae mg/m^3	P_2O_5 used by algae mg/m^3
Oslo Fiord at Dröbak	about 50	57	107	9	77	10
North Sea ...	8	0	8	15	18	18
Oslo harbour .	over 600	450	over 1050	over 150	2378	155

It was found that *Chlamydomonas* grew well in water containing excess of phosphate to which ammonium chloride had been added, while the addition of alanine, glycocoll, asparagine or urea promoted growth to a much less extent than either nitrate or ammonium. It is indicated that amide nitrogen can serve as a source of nitrogen when present in relatively great concentration.

An experiment was made on the growth of a pure culture of *Carteria* in water heavily enriched with phosphate, nitrate, nitrite and ammonium. This showed that the nitrate, and perhaps nitrite, was utilised faster than the ammonium.

The second part of this interesting paper deals with the loss of organic matter from growing algal cells into the surrounding culture medium. Such a loss was found to have occurred at the end of one month's growth of a pure culture of *Carteria* and at the end of two and a half months

growth of a pure culture of *Chlamydomonas*; on microscopical examinations the algae appeared to be quite fresh and vigorous ("vollkommen frisch"). It is considered that such unicellular algae give off much of the organic matter which they synthesise into the surrounding water while they are till alive. H. W. H.

H. Friedrich. Mitteilungen über vergleichende Untersuchungen über den Lichtsinn einiger mariner Copepoden. Zeitschrift f. vergleich. Physiologie, Bd. XV, H. 1, pp. 121—138. Berlin, 1931.

In an opening contribution on the visual sense of marine Copepods, H. Friedrich takes two species showing definite photopositive movement (*Calanus helgolandicus* and *Corycaeus anglicus*), and describes their behaviour under the influence of two parallel beams of light intersecting at right-angles. In these species two very different types of Copepod eye are represented.

The most noteworthy result obtained from *Calanus* was the interesting discovery that animals moving up a parallel beam are regularly deflected round into a beam intersecting at right-angles, even though the intensity of the second beam may be considerably less than that of the first. This provided a definite contrast to the behaviour of *Corycaeus*, which acted more in accordance with the simpler state of affairs in which both lights exert like influence.

Movement up the diagonal between the two beams was observed in both species, but this was varied, especially in *Calanus*, by sudden changes in the direction of one or other of the two light sources. To account for various deviations and irregularities in the paths of the animals tested, suggestions for interpretation in terms of alternating "tropotaxis" and "telotaxis" are put forward. Perhaps, however, it is unfortunate at thi stage to introduce expressions which are now used for the special purpose of describing relations between stimulation of sensory receptors and body movement, and which confine interpretation within artificially defined limits. Perhaps also the author appears too inclined to assume that the animal is under the dominating influence of light the whole time it is under observation, an assumption that may well be questioned in cases when typical actions are not regularly repeated. G. M. S.

A. C. Gardiner. The Validity of Single Vertical Hauls of the International Net in the Study of the Distribution of the Plankton. Journ. Mar. Biol. Assoc. N. S., vol. XVII, no. 2. Plymouth, 1931.

Es wird die Frage behandelt, ob einzelne vertikale Plankton-Fänge ein zuverlässiges Bild von der Menge des vorhandenen Planktons ergeben.

Zu den Versuchen wurde das Standard-Netz aus Gaze Nr. 3 benutzt. Während zweier Nächte wurden vor der Tyne-Mündung innerhalb 16 bzw. 12 Stunden hintereinander 40 bzw. 38 Fänge in demselben Gebiet bei treibendem Schiff gemacht und die Ergebnisse der einzelnen Fänge miteinander verglichen. Zur Ergänzung der hierbei erhaltenen Resultate dienten die auf einer Untersuchungsfahrt vor der englischen Küste zwischen

Flamborough Head und der Tyne-Mündung auf 21 Stationen gemachten Vertikal- und Horizontal-Fänge. Es wurden die Copepoden, welche in den Fängen am zahlreichsten waren, berücksichtigt.

Die Zahl der in zwei Fängen erbeuteten Copepoden kann sehr verschieden sein, auch wenn diese zwei Fänge zeitlich dicht aufeinander folgen. Jedoch liefert die Mehrzahl (etwa $^4/_5$) der Fänge Zahlen, bei welchen die Abweichung von dem aus allen Fängen berechneten Mittelwert nicht mehr als $\pm$ 33 % beträgt. Man kann daraus schliessen, dass einzelne Fänge doch recht zuverlässige Werte ergeben. Wenn aber die Ergebnisse von zwei Fängen auf derselben Station oder auf benachbarten Stationen stärker als oben angegeben voneinander abweichen, dann muss man ungleichmässige Verteilung des Planktons annehmen. Denn es zeigte sich, dass methodische Fehler, wie z. B. wechselnde Zuggeschwindigkeit des Netzes und Fehler beim Auszählen des Fanges, als unwesentlich vernachlässigt werden können. Auch der Einfluss von Licht und Dunkelheit auf das Plankton und Schwarmbildung innerhalb eines begrenzten Gebietes braucht man nicht zu berücksichtigen. KÜNNE.

F. S. Russell. The Vertical Distribution of Marine Macroplankton. X. Notes on the Behaviour of Sagitta in the Plymouth Area. Journ. Mar. Biol. Assoc. N. S., vol. XVII, no. 2. Plymouth, 1931.

In one of his earlier papers in this series Mr. RUSSELL summarised the vertical movements of Sagitta as shown by serial townettings at successive depths, taken at intervals through 24 hours. A re-examination of the material, supplemented by fresh collections, has shown that a reconsideration of the results was necessary, both because two species, *Sagitta setosa* and *S. elegans*, had been included under the single name of *S. bipunctata* and because it was found that the distribution of small specimens differed very materially from that of the larger, no separation of sizes having been made in the earlier paper.

In the present paper the vertical movements of each species, divided into 2 mm. groups, have been summarised and in part expressed as diagrams, and their implications considered in the light of Mr. RUSSELL's two basal theories of the vertical migration of plankton, viz., that for each group of animals there is an optimum illumination which determines the depth round which they are grouped, each group following the optimum condition up and down with the variation in the daylight, and that when the light stimulus is removed at night they are free to scatter at random till with the returning light they again concentrate in the region of optimum illumination. Although the movements of Sagitta as shown by these observations do to some extent support these theories, they are by no means entirely in accord with them. What appears most clearly from the data is that in daylight the younger stages are distributed much higher in the water than are the older ones, and that at dusk they reach the surface first, following according to the theory their optimum light intensity. The movements of the older stages are not so easy to understand. According to the author's view they are left free to wander at random by the disappearance of the light before they have had time to reach the surface,

but the recorded observations seem to suggest that they still continue their upward movement during darkness, for there is distinct evidence that the main body of the larger specimens both of *S. elegans* and *S. setosa* is higher in the water at dawn or at any rate after midnight than it is at dusk, and to effect such a distribution the ascent must have been continued during the night. The pursuit of the ascending optimum does not explain such a case.

The latter part of the paper is concerned with an attempt to correlate the observed movements of Sagitta with the probable conditions of illumination at the various depths at the time when the townettings were taken, and in this connection the author gives two most instructive diagrams showing the light intensities beneath the surface at different hours for waters of two different opacities. The movements do not fall into line with a simple theory of an absolute optimum illumination, for some of the Sagittas begin at dawn to move downwards and concentrate beneath the surface under an illumination much fainter than the optimum under which they were found during the day. This, as the author points out, involves a varying sensitivity, greater probably after a period of darkness.

The obvious lacuna in all the observations is the great distance intervening between the lowest townetting, ca. 35 metres, and the bottom, ca. 50 metres. If, as some of the diagrams suggest, the bulk of the Sagittas of any particular size have at any time descended below the reach of the townet, the representation of the percentage vertical distribution of the remainder may give a very erroneous picture of the true distribution. There seems, however, to be no satisfactory alternative method of presenting the results, for a diagrammatic representation of the actual numbers present may be even more misleading owing to the great irregularities in horizontal distribution which undoubtedly occur. G. P. F.

J. Schiller. Über autochthone pflanzliche Organismen in der Tiefsee. Biol. Zentralblatt. 51 Bd., pp. 329—334. Leipzig, 1931.

Schiller bezeichnet die Pflanzen, um die es sich hier handelt, als »die interessantesten Organismen des Meeres, die in der letzten Zeit bekannt geworden sind«. Es sind die von ihm in den Jahren 1912—1914 in der Adria nachgewiesenen, von Hentschel auf der »Meteor«-Expedition überall in der Tiefsee als vorherrschende Organismen des Nannoplanktons beobachteten »olivgrünen Zellen«. Sie fanden sich in der Adria in 150—1200 m Tiefe, im südatlantischen Ozean von etwa 50 m an bis zu über 4000 m als unregelmässig kugelige bis eiförmige Gebilde. In der Adria waren diese Zellen 3—5 μ gross, liessen eine deutliche Membran nicht erkennen und zeigten niemals Teilungsstadien. Im Atlantischen Ozean war eine Membran sicher nachweisbar. Die Grösse schwankte hier (wie der Referent den Angaben des Verfassers hinzufügen möchte) zwischen 5 und 15 μ, und es wurden Zweiteilungen innerhalb der Membran gelegentlich beobachtet. Die olivgrünen Zellen gehören vermutlich zu den Cyanophyceen und zwar den Chroococcales, vielleicht aber auch zu den Cyanochloridinen (Chlorobakterien). Sie stellen zweifellos eine eigene Vegetation der Tiefsee dar. Es ist unwahrscheinlich, dass sie sich vermöge ihres

Farbstoffes photosynthetisch ernähren. Eine autotrophe Ernährung durch Chemosynthese organischer Stoffe nach Art gewisser Bakterien wäre denkbar. Wahrscheinlich sind sie jedoch heterotroph auf Grund gelöster organischer Substanzen der Tiefsee. Der Referent möchte zu dieser Frage daran erinnern, dass nach Experimenten von Harder Cyanophyceen sich wenigstens 90 Tage lang im Dunkeln von gelösten organischen Substanzen ernähren können. Schiller kommt zu dem Schluss »Die Tiefsee hat also selbst Produzenten oder Schaffer«. Diese Auffassung wäre doch wohl nur bei autotropher Ernährung der olivgrünen Zellen berechtigt, nicht aber, wenn die Erzeugung ihrer Nährstoffe in letzter Linie doch auf das Pflanzenplankton der obersten Wasserschicht zurückgeht. E. H.

A. Hagmeier. Die Bodenfauna der Ostsee im April 1929 nebst einigen Vergleichen mit April 1925 und Juli 1926. Ber. d. deutsch. wiss. Komm. f. Meeresforsch. N. F., Bd. V, Heft 3. Berlin, 1930.

A prospective reader of this paper is recommended to turn directly to the concluding summary, which gives an excellent idea of the results of this faunistic survey. He will then be able to extract, without difficulty, such particulars as may interest him from the text account of the different sub-regions investigated. As in many papers dealing with this subject, the text, of necessity, practically assumes the character of a catalogue and, equally of necessity, becomes vexatious to comprehend properly if read without previous reference to the summarized results.

This investigation took place in April 1929 and includes the results of 203 samples taken with the Petersen grab (area = 0.1 sq. m.). The region sampled can be separated into three areas according to the predominant species found in them.

(1) The West Baltic area includes Kiel Bay, Fehmarnbelt and Mecklenburg Bay and carried the greatest weight of bottom fauna per sq. m., which, however, was largely due to *Cyprina islandica* and *Astarte borealis* — bivalves which are not very suitable as food for fish. Total weights per sq. m. (figures in brackets = without *Cyprina* and *Astarte*) were:— Kiel Bay 72—342 g. (2—75 g.); Fehmarnbelt 19—255 g. (19—55 g.); Mecklenburg Bay 169—208 g. (13—62 g.). The population, especially in Mecklenburg Bay, was less in 1929 than in 1925 and 1926. *Syndosmya alba*, though common in 1925 and 1926 was wholly absent in 1929.

(2) The East Baltic at depths less than 70 metres, has a more uniform population, which is dense only where the characteristic species *Tellina baltica* is abundant (Kadetrinne, Tromper Wiek, E. of Middle Bank, slope of Danzig Basin). Total weights per sq. m. varied from 85 to 223 g.; Arkona Basin was thinly populated (5—17 g. per sq. m.), while the shallow banks (Plantagenet Ground, Oder Bank, Rönne Bank, Stolpe Bank) had a varied population containing *T. baltica* and, characteristically, *Cardium edule*. On the Oder Bank a few places carried more than 50 g. per sq. m., elsewhere the quantity was less. In general the shallower spots were the most sparsely populated.

(3) The East Baltic at depths over 80 metres only carried a dense population where *Tellina calcarea* was common, especially in the deeper

region to the N. and E. of Bornholm (2—193 g. per sq. m.). In the deeper parts of Danzig Bay there were only 28—37 g. per sq. m.

Tellina baltica and *calcarea* are both suitable food for fish, the former species apparently predominating in the southern and the latter in the northern part of the area.

Of worms the commonest species appeared to be *Nephthys ciliata* or *Scoloplos armiger*, according to locality. Among the Amphipods *Bathyporeia pilosa* and two species of *Pontoporeia* occurred frequently.

Kiel Bay was the area richest in species but the slope E. of Hela, in Danzig Bay, was the most abundantly provided with suitable fish-food (224 g. per sq. m.). In comparison to 1925 and 1926 the West Baltic showed a decrease in population and especially in available food, owing to the disappearance of *Syndosmya alba*. On the contrary the Eastern Baltic showed little diminution except on the Stolpe and South Middle Banks.

J. A. R.

A. Hagmeier. Eine Fluktuation von *Mactra* (*Spisula*) *subtruncata* da Costa an der ostfriesischen Küste. Ber. d. deutsch. wiss. Komm. f. Meeresforsch. N. F., Bd. V, Heft 3. Berlin, 1930.

This paper is the record of a strictly localised quantitative survey of a twenty mile stretch between Borkum and Norderney, from 10 to 13 miles in width, between the 8 and 27 metre lines. Voyages were made in June and October 1925; March, May and September 1926; September 1928 and May 1929; and included 795 stations. The bottom was mainly fine variegated sand with occasional strips of coarser and some of muddy sand. A (0.1 sq. m.) Petersen grab and a Knudsen bottom-sampler were used — chiefly the former.

The fauna was not rich; there were 20 species of Lamellibranchs, 3—5 sp. Gastropods, 25 sp. Worms, 17 sp. Crustacea, 7 sp. Echinoderms and Amphioxus.

Tellina baltica and *fabula*, apart from *M. subtruncata* in 1928, were the commonest bivalves. Crustaceans and worms were numerous but light in weight, whereas Echinoderms were so heavy as to be excluded from the calculations. Of the worms *Pectinaria koreni* occurred in great numbers inshore in June 1925.

The sudden appearance of masses of *Mactra subtruncata* in 1928 and their equally abrupt disappearance in 1929, form the chief subject of the paper. In comparison with other years their numbers were higher over the region as a whole, but certain patches were densely populated. Two (possibly 3) such patches were discovered, the richest of which lay closest inshore and had an extent of not more than two miles from E. to W. Dr. Hagmeier computes the original population after spatfall at $\pm$ 800 per 0.1 sq. m. of which 250 died at the end of their first year and 300 more during their second summer. Comminuted shells were disregarded.

He derives the l_1 of *subtruncata* from the size of the white umbonal area of the shell. The masses of 1928 were probably spawned in 1927. Time of spawning and suitability of habitat probably account for size differences. The length varied from 3 to 13 mm. in the first autumn, and

from 17 to 25 mm. in the second, growth being greater on the densely populated patches than elsewhere. Differences of 1—3 mm. in the l_1 and of 1.5—4 mm. in the total length are found between the two situations. Dr. HAGMEIER agrees with DAVIS that *subtruncata* is fastidious as to soils, but as he found it on coarse, fine and even muddy sand he considers that the position of the ground and its relation to spat-bearing currents is also of great importance. He says that the bottom must possess certain (unspecified) physical peculiarities and attributes mass development to appropriate current strength and direction, taken in conjunction with the duration of planktonic larval life. The resultant currents of the region are little known but probably flow from W. to E., and, in view of finding a similar bottom fauna, with patches of *subtruncata*, off Ameland in 1929, the author makes the interesting suggestion that animals on this latter ground are derived from spat originating from the Dogger and in turn may give rise to patches off Borkum. This suggests an anti-clockwise distribution of *subtruncata* in conformity with the known circulation in the North Sea. Some scattered observations of patches off the Elbe and along the Danish coast are recorded.

In 1929 *subtruncata* had almost vanished from the region and had thus survived for $1^1/_2$ years only, suggesting a roughly annual life-cycle. DAVIS has shown that they may mature as 0-group animals. Dr. HAGMEIER attributes their disappearance to (a) high mortality and (b) failure of the young brood — two pregnant causes of extinction with which few will disagree.

Natica alderi, *Ophiura texturata*, which destroy young animals, and *Asterias rubens* are *subtruncata*'s chief foes. *Natica* appeared in numbers and disappeared with its prey, whereas *Ophiura* survived.

These are more or less sedentary animals, but plaice can migrate in search of food and were found to be feeding heavily on *subtruncata* in 1928. In this year the size of I—III-group fish was 2—5 cm. greater than in 1925 and 1926, probably indicating accelerated growth which may quite easily be attributable to their food. The evidence to show that these fish have been constantly on this ground is probably too slender to justify the author in assuming the validity of a direct relationship. If it be true, the disappearance of *subtruncata* in 1929 should be reflected in a diminution in the size of the plaice. J. A. R.

A. Sklower. Die Tierwelt vor der samländischen Ostseeküste und ihr Zusammenschluss zu Lebensgemeinschaften. Zoolog. Anzeiger Bd. 92, Heft 9/10. Leipzig, 1930.

The chief interest of this paper lies in its description of the sparse littoral fauna of the Baltic, which displays marked changes, both in species distribution and in their maximal size, as one penetrates into regions of progressively lower salinity. The district investigated lay between Brüsterort and Cranz (Samland), extending 4 km. seawards to depths of 25—40 metres.

The number of species that occurred are:— 2 sp. Coelenterates, 1 sp. Decapod, 5 sp. Isopods, 1 sp. Cirripede and numerous Amphipods, which are the most important group as regards fish-food and may occur in such

numbers as to destroy nets and lines. There are several Lamellibranch species which form a source of food, especially for flatfish, but there is only one Gastropod, the brackish or fresh-water *Neritina fluviatilis*. There are 2 sp. Polychaetes, 2 sp. Nemertines and one Bryozoan; *Nereis diversicolor* is important as fish-food.

The decrease in number of species accompanying decrease of salinity from west to east is shown by the following figures for invertebrates:— Kattegat 726 sp.; Kiel Bay 205 sp.; Baltic basins 47 sp.; Gulf of Bothnia 18 sp. Marine fish also decrease in number, but freshwater fish increase from W. to E. Decrease in size is also evident; e. g. max. size of *Nereis diversicolor*: North Sea 20 cm.; W. Baltic 13 cm.; Samland 9 cm.; Frisches Haff 6 cm. This is reversed in freshwater species (*Cordylophora lacustris*, *Neritina fluviatilis*), while marine species grow to a greater size in the higher salinity of the deep basins of the E. Baltic than in the area surrounding them.

Salinity, temperature, oxygen and CO_2 content are probably the factors responsible for these changes. Surface temperature may vary by 9 to 12° C., enormous salinity variations occur and in places, such as Gotland Deep, oxygen may be so deficient (and CO_2 tension so high) that only the worm *Scoloplos armiger* can survive.

Dr. Sklower uses the "Community" concept, but would have it completed and better defined for the purposes of pure biology and zoogeography. He mentions a *Syndosmya alba* community in Kiel Bay, which further east, owing to the disappearance of the predominant species and its replacement by *Tellina calcarea*, takes the name of the latter species. This surely is a cogent argument against the use of a system so labile that real distributional affinities may be obscured by conventional terminology.

Dr. Sklower divides the coastal area into seven transitional regions from the land seawards. (I) The upper beach is largely populated by land animals and by the semiterrestrial *Talitrus saltator*. (II) Sandy shore, exposed to wave action, is thinly populated, chiefly by shrimps, *Sphaeroma rugicauda*, sandeels and young flounders. (III) Stones covered with algae have a rich fauna, mainly Crustacea, particularly *Gammarus locusta* which also occurs with *Neritina fluviatilis* in huge numbers on (IV) harbour-works and piles. This latter habitat has a very similar fauna but includes more sedentary species. *G. locusta* is so common that this habitat, insignificant in extent though it must be, is considered to be one of the chief productive areas for fish-food! (V) Floating sea-weed has a partly adventitious and partly free-swimming population. (VI) The free sandy littoral is chiefly characterized by paucity of Amphipods and the presence of bivalves and fish. (VII) The deeper littoral, especially where mud is present, carries the large and important *Mesidotea entomon*, a favourite food for cod and, besides *Nereis diversicolor*, the sea mouse (*Polynoe cirrata*). J. A. R.

James S. Gutsell. Natural History of the Bay Scallop. U. S. Dep. of Comm. Bull. Bureau Fish. Vol. XLVI, 1930. Fish. Doc. no. 1100. Washington, 1931.

The Bay Scallop (*Pecten irridians* Lamarck) in commercial value ranks third among the economically important molluscs of America. The present

paper deals mainly with those aspects of the life history which it was thought would yield results useful in the conservation of the fishery. There are sections dealing with classification, distribution, structure and habits. Spawning and development are naturally treated upon at some length. In North Carolina, where sexual maturity is reached within one year, spawning was found to occur in late summer, autumn and early winter, but mainly in autumn. Some useful data are given on the larval and post-larval development, together with some information as to growth, age at maturity and length of life. Environmental factors are discussed briefly, while there is a section dealing with the enemies and parasites of the Bay Scallop. The importance of a knowledge of the life history of the species in connection with protection is emphasised. The paper is well illustrated with photographs and line drawings, and it is a welcome addition to the literature on this group. F. S. W.

F. W. Weymouth and **H. C. McMillin.** Relative Growth and Mortality of the Pacific Razor Clam (*Siliqua patula* Dixon) and their bearing on the commercial fishery. U. S. Dep. of Comm. Bull. Bureau Fish. Vol. XLVI, 1930. Fish. Doc. no. 1099. Washington, 1931.

The species dealt with in this paper, the Pacific Razor Clam (*Siliqua patula* Dixon), is a mollusc of some economic importance, and the authors' endeavour has been to secure data which might be applied towards the conservation of the supply. The fact that the growth rate and breeding habits vary widely in different parts of the extensive range of the species, is shown to require regulations adapted to the locality. Several tables and graphs are given showing the growth rate of the Razor Clam in various regions, the age being determined from the number of growth rings present on the shells. The manner in which the biological data may be used for the regulation of the fishery is fully discussed, and the paper is a valuable one as showing how such problems should be attacked. F. S. W.

F. W. Weymouth and **Seton H. Thompson.** The Age and Growth of the Pacific Cockle (*Cardium corbis* Martyn.). U. S. Dep. of Comm. Bull. Bureau Fish. Vol. XLVI, 1930. Fish. Doc. no. 1101. Washington, 1931.

In this paper, the authors give the results of their investigations into the age and growth of the Pacific Cockle (*Cardium corbis* Martyn). The age has been deduced from the number of growth rings present on the shells. In the present case, this method seems to have given results of considerable accuracy, although, in *Cardium edule* and some other European lamellibranchs, on the other hand, it is certain that more than one ring may sometimes be formed in a single year as the result of exposure, injury or other causes. The species dealt with has a wide distribution along the Pacific coast of America. In the northern part of its range it has a lower initial growth, a longer life, and attains a larger size than in the southern parts. Several useful graphs are included showing the relation between age and growth and other points discussed in the text. F. S. W.

Aage J. C. Jensen. Investigations of the Plaice Stock in the Southern Horns Reef Area in the Years 1928—1930. Medd. fra Komm. for Dan. Fisk.- og Havundersøgelser. S. Fiskeri, Bd. IX, Nr. 2. København, 1931.

It is by no means intended as any disparagement of Mr. JENSEN's work when the view is expressed that it is the section dealing with the development of the Danish fisheries rather than the part devoted to the scientific investigations which should be studied with the most profound attention by all concerned with the economics of fishing.

First, to deal with the scientific work; Mr. JENSEN shows that there was a decreased abundance of plaice in 1930 as compared with 1922 and 1925, basing his conclusions on the catch per hour of a research vessel. From past unfortunate experience such estimations are accepted with some hesitation unless substantiated by commercial statistics. With the Danish fishing there is considerable difficulty in producing such confirmation, since it is carried on by means of so great a variety in the sizes of the vessels that it is not possible accurately to calculate the catch per unit of time; consequently it is necessary to fall back on the commercial landings. The intensity of fishing for plaice, as Mr. JENSEN says, is dependent in Denmark on whether it is more profitable to catch plaice or haddock; the fact, therefore, that the landings in 1922 and 1925 were less than in 1930 in spite of a presumably larger stock does not prove that the research vessel figures were inaccurate but merely that the case is unproven, since in the earlier years haddock was more sought after and the number of Danish vessels was fewer. According to the »Fiskeri Beretning«, the landings of plaice do show a definite, small decrease of 3.5 per cent. in 1930 compared with 1929, while the landings of haddock rose; but Mr. JENSEN says that plaice are now more sought after than haddock. It is probable, therefore, that the landings of plaice in these two years can be compared and indicate a smaller abundance of plaice. Moreover, Mr. JENSEN produces further evidence from the commercial catches of plaice in the section dealing with the »Size Composition of the Population«.

The conclusions with regard to the relative frequency of plaice are in complete accord with those of the German and English investigators, and afford a valuable addition to our knowledge of fluctuations.

The question of the growth-rate of plaice is a very complicated one; in the reviewer's opinion it cannot be calculated from research vessel or even market samples. Such marked variations in size were found in the plaice caught in May and November by the English investigators during three years that it is difficult to believe that this method provides a reliable means of estimating growth-rate. The matter, however, is too lengthy to be dealt with in a review and is discussed fully in a report shortly to be published in the English Scientific Fishery Series.

When we turn to the very remarkable development in the increase in the yield of the Danish plaice fishery we come to a subject of fundamental importance. From the evidence produced there can be no doubt that the protective measures for sparing the undersized fish by means of a size limit, coupled with a gear which enables the fish below it to be returned to the sea alive, have been amply justified. The intensity of the Danish

fishing has increased by leaps and bounds and, at any rate up to 1929, the stock was able to produce, *pari passu*, a sufficient quantity of marketable plaice to increase the landings.

The contention that the sparing of undersized fish in a well fished area was undesirable since it led to over-crowding and the consequent production of a dwarf race has been disproved. It is inconceivable that a stock subjected to so intensive a fishing could, so to speak, have stood up to the fishing if marketable and unmarketable alike had been destroyed, as they would have been by trawling and with unrestricted landings of undersized fish for the meal factories. The remarkable intensity of fishing can be judged from the English marking experiment of 1929 when 44 per cent. of the plaice marked off the Danish coasts were returned in a year, and also by the fact that the Danes, fishing in the comparatively small part of the North Sea shown in Mr. JENSEN's chart, Fig. 7, landed in 1929 a greater weight of plaice than did the English vessels fishing the whole North Sea. From the Danish and English trawling experiments in the Horns Reef area it is evident that the great bulk of the plaice caught were below the Danish size limits; the destruction therefore of unmarketable fish, without these beneficial measures, would have been enormous.

Mr. JENSEN deserves the thanks of all who are working for the improvement of the fishery for his clear exposition of the facts. D. E. T.-P.

W. Schnakenbeck. Zum Rassenproblem bei den Fischen. Zeitschr. f. Morphol. u. Ökol. d. Tiere. Bd. 21, H. 3/4. Berlin 1931.

The paper under consideration constitutes the main publication on the results to which Dr. SCHNAKENBECK himself has already given the readers of the Journal an introduction through his summary in Vol. VI, No. 1. The paper consists of two main sections, a general part which in actual space only constitutes one third of the whole, but which is printed in a rather unpleasantly small type so that it nearly equals in content the other section, the special part. In a short introduction to the general part the author gives an outline of the racial problems of fishes since HEINCKE's classical work on the herring and arrives at the somewhat disappointing conclusion that, since then, there has been little real progress made in the solution of the racial problems of the herring or of any other fish — a statement which does little credit to the enormous amount of work which has been done on this subject by various investigators. Although the fundamental question, whether the fish races are genotypically or phaenotypically determined, has not yet reached any final solution (and this is really the century-old question of evolution in a slightly specialised form), yet the racial investigations of the last 30 years cannot be overlooked; on the other hand they will prove to be one of the most important stages in elucidation of the racial problem insomuch as this problem demands observations over many years.

In the general section the author discusses very thoroughly the use of the terms species and race and the highly important, correlated question of the mutability of racial characters. He gives a lucid account of the many different attempts at a definition of these terms in connection with fishes.

It is doubtful whether or not there is any cause for distinguishing between the terms species and racial circle. Dr. SCHNAKENBECK himself mentions *Anguilla vulgaris* as the best example of a species according to RENCH's definition yet there is no reason why *A. vulgaris*, *A. rostrata* and *A. japonica* should not be regarded as three races belonging to the same racial circle as already indicated by JOHS. SCHMIDT (1915) in comparing *Anguilla* and *Zoarces* and, as the same author has later realised, in dividing the species or racial circle *A. australis* into the two sub-species or races, *A. a. orientalis* and *A. a. occidentalis*, which hardly differ more from each other than *A. japonica* and *A. vulgaris* for example.

The sexual aversion between races is pointed out as being very important, but, for the present, reliable information on that subject is lacking for such fishes as the eel, the herring and other salt-water fishes. The not infrequent crossings of different species of Cyprinidae under natural conditions as well as the facility in crossing very different races of fresh-water fishes in aquaria seem rather to indicate that it is only the state of maturity which determines the sexual attraction between two individuals of the same species.

In the chapter on the mutability of racial characters the author mentions the influence of external and internal factors upon the development of organisms and deals more particularly with the development of racial characters in fishes and the possibilities of influencing them. Reference is made to a phenomenon investigated by FORD and the author himself, viz., that abnormally developed caudal fins are extraordinarily numerous in samples of young herrings from the waters round Plymouth. In a single sample the author found that 37 % of the individuals were deformed but this phenomenon is explained as an aberration in growth under extreme conditions and not as a result of individual variation of the genotype. At this point, as also at others in the paper, one would have liked to discuss the effect of selection. The author points out an important and extremely interesting fact that in the herring the longer the time of development of the different fins the greater is the fluctuation of the racial characters. The long period of latent ventrals is of no importance; it is only during the short period of active development that small variations arise.

In a separate chapter the author criticises in detail the work of a number of scientists, especially those who claim to have found a correlation between external factors, temperature in particular, and the development of racial characters. In every case he is persuaded that the development of racial characters is unaffected by external influences but his criticism is by no means convincing. Thus the author cannot be said to have shaken the great universal correlation between the distribution of the average number of vertebrae and the temperature (particularly well exemplified in the herring and the cod) when one considers the whole distribution of the species. This is still more evident if one considers the "fjord phenomenon" described by Prof. JOHS. SCHMIDT, who, in the cases of the herring, the cod and *Zoarces*, has shown that the fjord races have a lower average number of vertebrae than those from more open waters. Space does not allow a more detailed review of this chapter but the criticized authors of papers on the subject (BJERKAN, HUBBS, LEA, JOHS. SCHMIDT and TÅNING)

can scarcely agree with Dr. SCHNAKENBECK. The use of percentage frequency curves appears very attractive but one gets the impression that the distinctions drawn are too fine; and without extensive experience it does not seem advisable to omit the calculation of the mean, the standard deviation and the mean error. There again doubts are raised regarding the value of *Zoarces* as a subject for general considerations of these problems, but until convincing experiments prove the opposite it is difficult to understand the asserted difference of a fundamental character between viviparous fishes like *Zoarces* on the one side and all oviparous fishes on the other. Consequently one might also distinguish between fishes with demersal and pelagic eggs. During development the individual egg in demersal egg masses, for example, will be exposed to an extremely variable supply of oxygen, possibly more variable than in the case of the egg of viviparous fishes. Neither does it seem reasonable to consider the variability in *Zoarces* as being exceptionally high; one is inclined to think that a fluctuation of about 10 for a species like the herring with about 55 vertebrae is of the same magnitude as a fluctuation of about 25 for *Zoarces* which has about 115 vertebrae. Besides it will be seen that a single sample of *Zoarces* exhibits nearly the same fluctuations in the number of vertebrae as *A. vulgaris*.

Dr. SCHNAKENBECK appears to place little value on experimental investigations on the influence of external factors, whereas most biologists regard this as the best means towards a more accurate analysis, provided of course the experiments are carried out with discretion.

By far the greatest interest lies in the special section of the paper. Every scientist who is investigating the races of fishes will profit by studying Dr. SCHNAKENBECK's methods and critical investigations of these characters which are the best and simplest for studying herring races. It is of great interest to know that certain racial features of the Bank herring and the Channel herring have remained constant for as long as 40 years, and from this we draw the important conclusion that the variability of the number of vertebrae under normal external conditions is constant and hereditary. To find in this, however, a proof that external factors have no influence at all is hardly warranted.

It must be admitted that the fry of the two aforementioned races must have been exposed to very variable conditions, but other circumstances must be considered such as shifting of the spawning grounds during the spawning season, changes in the beginning and end of the spawning season from year to year and the fact that it is not the numerical variations during the formative period which are conclusive but the result of the influencing temperatures and the corresponding intervals of time. Bearing these matters in mind we are led to doubt whether the resulting factor of the external conditions has been varying significantly at all.

Probably big races like these named can be better compared with *A. vulgaris* in which no variation of the average number of vertebrae has been found. The investigation of a small race of herring with a limited spawning area and a short breeding season would be of interest for the sake of comparison.

It is satisfactory to think that Dr. SCHNAKENBECK has taken up the

racial problem of the herring on the broadest basis so that the whole area of distribution is considered. Many aspects of the question are made clearer as a result and it is a pity that so few fishes have been dealt with in such a fashion. Only one point regarding the geographical distribution of the high and low numbers of vertebrae may yet be discussed. Dr. SCHNAKENBECK assumes that the general rule, that the number of vertebrae increases going from South to North, shows an exception on the Asiatic side of the Pacific Ocean. This appears to the reviewer to be a verification of the influence of temperature on the distribution of the number of vertebrae, for it is well known that the cold water of the Okhotsk Sea stretches a long distance southwards along the Asiatic coast so that one cannot compare samples regardless of their position in relation to the isotherms.

The reviewer does not attempt to summarise Dr. SCHNAKENBECK's paper but refers the reader to the author's own resumé in the Journal. It is hoped, however, that this review will serve to emphasise the value of this contribution to the literature on the racial problems of fishes — a contribution which, however, cannot be accorded that general value which the author himself appears to expect, but rather it will be valued as a special contribution giving a comprehensive picture of the races of herring and connected problems. Whether one agrees with the author in his views on the problem under discussion or not one can still read his paper with profit and it is warmly recommended to all biologists who are interested in these problems. ANTON FR. BRUUN.

Johs. Schmidt. Race Investigations X. The Atlantic Cod (*Gadus callarias* L.) and local races of the same. Comptes-Rendus des Travaux du Laboratoire Carlsberg, vol. 18, no. 6. Copenhague 1930. (Auch eine dänische Ausgabe in derselben Publikation.)

Diese wichtige Untersuchung gehört zu der Reihe, die mit *Zoarces viviparus* anfängt. Da *Zoarces* ein in allen Lebensstufen ausgesprochen ortsständiges Wesen ist, der Dorsch aber wegen der weitläufigen Verteilungen sowohl der Eier wie auch aller älteren Stadien bemerkenswert ist, bietet das von allen möglichen Gebieten zusammengebrachte reichhaltige Material ausgezeichnete Gelegenheit zum Vergleich der Variabilität zweier Objekte von fast entgegengesetztem biologischem Typ. Die folgenden Charaktere sind untersucht worden: die gesamte Wirbelzahl (V) und die Strahlenzahl der zweiten Rückenflosse (D_2), nachdem es sich gezeigt hatte, dass diese Merkmale die augenfälligsten Schwankungen aufwiesen.

Die Beobachtungen sind vollständig, mit berechneten Mittelabweichungen und »Fluktuation« der Durchschnitte (hiermit ist gemeint der mittlere Fehler multipliciert mit 3,4), die in Tabellen gegeben sind, die Durchschnittswerte sind ausserdem in einer Reihe von Karten dargestellt. Die allgemeinen Ergebnisse kommen in zwei sehr eindrucksvollen Symbolkarten zum Ausdruck: ein Zusammenhang zwischen niedriger Temperatur und hoher Wirbelzahl ist unwiderlegbar; ein solcher Zusammenhang mit der Temperatur könnte auch für das Merkmal (D_2) behauptet werden, wenn nicht die an Ostsee-Dorschen gewonnenen Ergebnisse gegen einen solchen einfachen Zusammenhang sprächen. Die hier lebenden Dorsche

zeigen nämlich hohes V und niedriges D_2, und eine solche Kombination spricht gegen die Annahme, dass die Riesendorsche der Ostsee nicht dort einheimisch sein sollten.

Die Ergebnisse deuten übrigens darauf hin, dass ein Zusammenhang besteht zwischen den isländischen und westgrönländischen Beständen, was auch durch Wiederfänge von markierten Grönlandsdorschen bei Island bestätigt worden ist.

Eine solche Untersuchung, die wegen der zeitraubenden Zählungen und des voluminösen Materials besonders kostspielig und anspruchsvoll ist, könnte schwerlich von einem staatlichen Fischereilaboratorium durchgeführt werden. Die Fischereiforschung ist daher dem Carlsberg Laboratorium wegen dieser grossen Leistung zu besonderem Dank verpflichtet.

O. S.

A. S. Jensen og **P. M. Hansen.** Undersøgelser over den grønlandske torsk (*Gadus callarias* L.). Universitetsbogtrykkeriet, København, 1930. 55 pp.

This is a short paper containing a wealth of material and information on the cod in West Greenland waters, the more interesting in view of the great cod fishery recently developed by several nationalities on the West Greenland banks.

The paper opens with an historical review of the fishery during the last century showing the extraordinarily variable character of the fishery, and this applies not only to the banks (where the fishery has not perhaps been tried regularly enough to warrant very decisive conclusions) but especially to the fjords where it must be supposed that the inhabitants will have become aware of any shoals of cod. In the XIXth century cod were plentiful in the 'twenties and again in the late 'forties, the remaining period being more or less barren. Only about ten years ago a new cod period set in.

The investigations which the paper summarizes are the following: the cruise of the "Tjalfe" in 1908 and 1909, directed by Ad. S. Jensen; Å. Vedel Tåning's investigations in 1924; work during the "Dana's" cruise in 1925 by Ad. S. Jensen; and Paul M. Hansen's work in 1926—1929.

The spawning of the cod in Greenland waters has been ascertained by the presence of spawny fish in early May in 1925—28 in some of the fjords up to a latitude of 67° N. which is considered the northern limit. The spawning seems to begin in April and to last into June. The bottom temperatures are very low in the spawning time, between 1.73° and —0.27°, with 2.53° to 5.60° at the surface. The greatest quantities of eggs taken during $^1/_2$ hour with a 2 metre net were 2200 and 1140 (which are indeed very small numbers compared to those habitually found at Iceland or Lofoten).

The fry were seen associated with jellyfish as in European waters. some young fish of the 0-group were obtained with a shore-seine in September and had a length of *5.29 cm.* It is thus demonstrated that there is a certain amount of spawning and also rearing of fry on the Greenland coast.

The age and growth were examined by means of otoliths on not very extensive material from a number of localities. The growth was found to be about the same as in the Iceland cod and considerably better than in the Norwegian cod stock. (The Norwegian material used for comparison is, however, incomplete in so far as it only includes fish from the mixed feeding shoals at Finnmarken. If spawning cod had been considered, there would still have been a difference but only about 10 cm. for the higher age-groups (not about 20 as shown in the graph p. 27).

It is shown that the main bulk of the catch in the years investigated consisted of only certain year-classes, namely 1912, 1917, 1922 and 1924, — 1922 being the best.

The food of the cod in Greenland waters is treated at length. The most important food is found to be caplin; next come sand-eels. Otherwise the Greenland waters seem to offer a variety of different food, benthic as well as planktonic.

In the years 1924 to 1929 in all 1976 fish were marked and the recaptures from the first four of these experiments are discussed. It is shown that the migrations are not very extensive. Of the 1367 fish liberated 55 were recaptured but only four had gone any distance, which is the more remarkable as the majority of the recaptures were made 1 to 4 years after liberation.

The time of appearance on the banks seems to be connected with the temperature and varies accordingly between different dates in the month of June.

The authors point out the changes in the marine fauna which have accompanied the recent immigrations of cod to Greenland waters, i.e. the appearance of saithe in considerable numbers. It seems even to have spawned there. Even a full grown haddock was taken in 1929, while such northern animals as the white whale, the caplin and the black halibut have greatly restricted their wonted southward migrations in the latter years. O. S.

H. C. Regnart. The lower limits of perception of electrical currents by fish. Journ. Marine Biol. Assoc. N. S., vol. XVII, no. 2. Plymouth, 1931.

The aim of Mr. Regnart's investigation was to determine the lower threshold of the sensitivity of fishes to electrical currents. His animals (goldfish as a type of fresh-water fish, codlings (*Gadus callarias*) as a type of sea-water fish) were kept in tanks into which two steel plates were fitted as electrodes. The goldfishes reacted to the completing and (in weaker form) to the breaking of the circuit in different ways, according to their position in the tank. The lower threshold was found at about 5 microampères per sq. cm. direct current. With the codlings the threshold was at about 15 microampères per sq. cm. direct current, and about 2 microampères per sq. cm. alternating current. With both animals the reactions became weaker when the stimuli were repeated, until finally no more effect was obtained.

The author then tried to find out what organs are to be regarded as

perceptors of the electrical stimuli. Elimination of the lateral organs and the skin of the anterior part of the head by cutting the afferent nerves made the fish less sensitive to the stimulus than they were before, but not totally insensitive. Even when after elimination of the lateral organs the optic nerves were cut on both sides, the sensitivity did not totally disappear. This result seems to indicate that other parts of the body also served as receptors, although certainly the lateral organs play the most important rôle. J. A. Bierens de Haan.

G. M. Spooner. Some observations on schooling in fish. Journ. Mar. Biol. Assoc. N. S. vol. XVII, no. 2. Plymouth, 1931.

The author in this paper tries to determine the external factors that cause the "schooling" of fishes. As subject for his experiments the bass (*Morone labrax*) was chosen, a fish that shows a strong tendency to form schools (especially when young) although not so definitely and persistently as for instance the herring or mackerel. The animals were kept in aquarium tanks and observed through a peephole in a black paper with which these tanks were covered. When glass partitions were set up to separate individuals the animals moved to each other and schooled on either side of the partitions. That these reactions were optically determined was clearly shown in a series of experiments with mirrors, placed in and removed to different parts of the tanks. The fishes then reacted to their images in the mirror in the same way as to other individuals, turning back to the mirrors when they were driven away, etc. To show the influence of a mirror on the distribution of a greater number of fishes a mirror was placed in one of the two compartments of a tank, and the number of fishes that gathered in each compartment counted and expressed in a graph. Removal of the mirror to the other compartment was followed by a gathering of the fishes in that half of the tank.

The author then tried to determine what part of the total appearance of the other fish or the image is essential in attracting the animals: form, movement or pattern. As a dead fish showed the same attraction as a living one, the movement of the animals does not seem to play a rôle. On the other hand the fishes were not attracted and even repelled by rough models in plasticene or tinfoil, which shows that an object is wanted that clearly resembles a living fish. Experiments in which parts of the fish were reflected in small mirrors proved that a complete image is not necessary to obtain a reaction, but that this image must be nearly complete. For instance the head alone does not exert attraction. J. A. Bierens de Haan.

A. G. Huntsman. The Maritime Salmon of Canada. The Biological Board of Canada. Bulletin No. XXI. Ottawa, 1931.

In an introductory account of the general life-history of the Atlantic salmon, the author propounds twenty-two problems which require solution before our knowledge can be considered in any way adequate. In this report he tries to solve some of them by a detailed analysis of the statistics of the salmon landed in the Maritime region during the period of 61 years from 1870 to 1930.

The Maritime region comprises Nova Scotia, New Brunswick, Prince Edward Island and part of Quebec and includes the southern shores of the Gulf of St. Lawrence stretching from Cape Gaspé on the north to the Bay of Fundy on the south. This area contains very valuable salmon fisheries which have been exploited for a long period both commercially and for sporting purposes. The maximum catch was made in 1873—74 and was followed by a rapid decline to a minimum in 1881. Since then there has been, on the whole, a steady improvement accompanied by such fluctuations as appear to be normal for the salmon throughout its area of distribution. The object of the present investigation is to discover the factors which determine these fluctuations and to ascertain if there is any periodicity in their recurrence. Dr. Huntsman finds that his statistics indicate that periods of general scarcity of salmon occur every 9.6 years. Five of these periods comprise a major period of 48 years exactly. Mr. F. Gray Griswold has already noted a periodicity of about 9 years in both rod and commercial catches of New Brunswick and Quebec, which he attributes to a periodic variation of nine years in the tides. A periodic abundance in certain fur-bearing animals of western Canada has been reported, the duration of the period being in many cases between 9 and 10 years. Storrow has claimed to find indications of an 18 to 19 year period in the fluctuations of the catch of salmon in the Tyne (Salmon and Trout Magazine, No. 51, 1928, p. 128), and suggests that it may be due to alternation in the 9 year tidal period. On the other hand, Huntsman (p. 12) believes that the effect, whatever it is, is exerted on the salmon during its early life in freshwater and whilst disclaiming any knowledge of the cause which produces the fluctuations thinks that "The wide extent of its effects and the definiteness of the period point to an astronomical origin".

Periodicities of smaller duration than 9.6 years are attributed by Huntsman to the predominance attained by certain lines or series of generations, analogous to the four year period of the sockeye salmon of the Fraser River. He finds even smaller periodicities of two, three and four years which he considers are due to competition and cannibalism among the salmon during their early freshwater life. Apparently he does not attribute any importance to weather conditions as a factor in determining the size of the catch. In the British Isles we find that a dry season is favourable to net catches whilst a wet season accompanied by numerous floods in the rivers is very unfavourable. He says (p. 27) "If the fishing effort remains constant, fluctuations in the fishery represent fluctuations in abundance".

It is very doubtful whether the life-history of the salmon in the Maritime region is sufficiently well known to justify the use he makes of it to explain the smaller periodicities.

In discussing the results of marking experiments, Dr. Huntsman distinguishes between "river maturity" and "spawning maturity" and appears to be greatly influenced in making this distinction by the fact that some of the fish liberated after stripping at the hatcheries continue their upstream migration. This phenomenon is so well known that at many of the hatcheries in Ireland the stripped fish are held in ponds until

the traps have ceased to work so that they will not be captured a second time. But there is no evidence that fish which have spawned naturally continue afterwards to travel upstream.

The great majority of fish which spawn for a second time do so after an interval of two years.

There are two main runs of salmon in the Maritime region, the first in June, the second in early October. There is a tendency nowadays to regard such runs as belonging to distinct races. Dr. HUNTSMAN points out that for more than 80 years commercial fishing in the Maritime region has been concerned only with the earlier run, the later run being of poorer quality and enjoying greater protection owing to the approach of the spawning season. On the other hand the renewal of the stock has depended to a large extent on the later run. Nevertheless the ratio of the two runs does not seem to have altered, so that it would, in Dr. HUNTSMAN's words, "be most extraordinary if the two runs were found to consist of distinct species". R. S.

W. L. Calderwood. Salmon Hatching and Salmon Migrations. Edward Arnold & Co. London 1931.

Alle Lachse entstammen dem Süsswasser. Wie CALDERWOOD erzählt, legt die Lachsmutter die Eier in Vertiefungen, die sie im kiesigen Flussbett aushölt und das Männchen spritzt die Milch darüber; ausserdem verteilt ein grosses Weibchen die Ablage der Eier auf 8—10 Tage und auf verschiedene Laichgruben. Ein Laichplatz sieht somit oft aus wie eine Landschaft mit Berg und Tal und Steinen in Grösse eines Balles bis zu Handgrösse; ein Zerdrücken der elastischen Eier zwischen den Steinen findet nicht statt. Wohl aber werden sie von Feinden decimiert. Die Forelle verschlingt viele Lachseier, ebenso der Aal, tauchende Enten, Insektenlarven. Die jungen Lachse werden vom Cormoran, Merganser usw. verfolgt. Aber tote oder unbefruchtete Eier hat Mr. CALDERWOOD bei seinen vielfachen Beobachtungen nur vereinzelt bemerkt.

STEPH. LUDW. JACOBI aus Hohenhausen (Lippe-Detmoldt) übte die *künstliche Befruchtung* der Eier der Forellen schon 1725 aus: Veröffentlicht 1765 im »Hannöverschen Magazin«. Die künstl. Befruchtung und Versendung der Eier nahm stärkeren Aufschwung seit 70—80 Jahren und erfolgt weit über See seit Ende vor. Jahrh. — Verschiedene Forellenarten sind jetzt von England aus in Neu-Seeland, Tasmania, New-South-Wales und Ceylon eingebürgert.

Nach langen Fehlschlägen gelang dann die Einführung des *Quinnat* Salmon von der Pazifischen Küste nach *Neu-Seeland* in den Fluss Waitaki auf der Südinsel.

Ähnlich gut ist die Verpflanzung des vielgepriesenen *Sockeye* Salmon (*Oncorhynchus nerka*) von Canada nach Neu-Seeland gelungen. Jetzt werden die Eier ohne Wasser in Trögen und isolierten Kästen mit Eis in der Kühlkammer des Schiffs, aber nicht unter dem Gefrierpunkt, ganz wenig darüber, versandt. Der *O. nerka* hat sich der antipodial season angepasst und im März/April gelaicht.

Im Jahre 1908 (8 Jahre nach dem Erfolg mit dem Quinnat) wurden eine Million Lachseier, und dann nochmals, in einer Brutanstalt der

Südinsel Neu-Seelands aufgezogen. Sie stammten aus Grossbritannien, und wurden von Mr. Tate Regan und Mr. Calderwood als echte Lachse festgestellt — damit als eingebürgert in Neu-Seeland legitimiert. — Auch Browntrout war eingeführt.

Über die Verhältnisse der Lachsfischerei in Nordamerika besteht eine gewaltige Literatur, entsprechend dem Umfange des Lachsvorkommens im Westen, repräsentiert durch die verschiedenen *Oncorhynchus*-Arten. Die Brut des Atlantischen Lachses zeigt wesentliche Abweichungen vom *Oncorhynchus*. Aber das Bedeutsamste ist doch immer, mit welchen Zahlen in Nordamerika gearbeitet wird: 1925 wollte man feststellen, wie viele Sockeye in den Cultus-lake aufstiegen. Es wurde ein Wehr querüber den Fluss errichtet. Es wurden so 1540 ♂ und 3883 ♀ gefangen. Eine gewisse Zahl der ♀ wurde getötet und im Durchschnitt pro Fisch 4500 Eier gezählt und daraus 17.473.500 Eier errechnet. Die 17 Millionen Eier wurden der natürlichen Erbrütung überlassen (left to hatch naturally; p. 46).

Unser europäischer Lachs bringt die längste Zeit seines Lebens in See zu und verfolgt hier die Schwärme des Herings, der Makrelen, Sprotten und Sandaale und bleibt 1—4 Jahre ohne Verbindung mit dem Lande, — im Gegensatz zu der Meerforelle, die in den Flussmündungen und entlang der Küste lebt. Die Treibnetzfischerei auf Lachs wird nur vor gewissen Teilen Irlands betrieben, ebenso vor dem östlichen Canada, ferner im Skagerrak (durch Makrelen-Fischer). In der Nordsee ist der Lachsfang beschränkt, eine Karte (Fig. 3, S. 61) gibt die Hauptfangplätze an, die sich bis zu den Shetlands erstrecken.

Der Verfasser weist (p. 64 ff.) ferner darauf hin, dass zahlreiche Quinnat westlich von Vancouver Island markiert und im Sacramento (Californien) in 850 miles gerader Entfernung wieder gefangen sind. Von Alaska (Ikatan Bay) sind markierte Fische in grosser Zahl zur Bristol Bay in der Bering-See gewandert (400 miles). Ein Fisch von Alaska, der seinen Weg nördlich der Halbinsel anscheinend nicht fand, folgte der Linie der Aleuten westwärts, bis er die asiatische Küste in Kamchatka erreichte, wo die Japaner den Lachs fangen. Nach Calderwood ist das ein Weg von ca. 1000 Meilen. Und Prof. Knut Dahl erzählt, dass ein alter Schipper, der von Neufundland zurückkehrte, eine Leine auslegte, um eine Chance für seinen Topf zu haben. Er fing einen Lachs, und zwar halbwegs zwischen Neufundland und Rockall. Ausser Rockall ist das eine Entfernung von über 1000 Meilen von jedem Lande.

So erklärt sich, dass der Atlantische Lachs an beiden Seiten des North Atlantic vorkommt und der *Oncorhynchus* an beiden Seiten des Nord-Pazifischen Ozeans.

Aber Calderwood macht darauf aufmerksam, dass in Schottland über 30 Jahre lang Lachs markiert wurde; trotzdem ist niemals ein Wiederfang in Norwegen vorgekommen. Nur einmal war ein markierter Norweger Lachs in einem Londoner Fischladen gefunden, — aber der Lachs hatte die Nordsee auf einem Steamer passiert.

Wenn die Lachse aus See die Grossbritannische Küste wieder aufsuchen, geschieht das als »early runs, summer runs und late runs«. Nach 1—2 Wintern, Ende März und Anfang April, erscheinen die »Grilse« an der schottischen Küste.

Es folgt eine recht eingehende Besprechung der schottischen Verhältnisse, die ohne eine genaue Karte nicht leicht zu verstehen sind. Calderwood ist erfreut, dass Versuche, eine Netzfischerei in der offenen See vor Schottlands Küste zu entwickeln, völlig fehlgeschlagen sind: »We cannot both have our cake and eat it«.

Zum Schluss seines Buches erörtert Calderwood noch die sehr auffallende Tatsache, dass es eine »spring« chinook fry gibt und eine »fall« chinook fry. Ein Bericht darüber ist 1929 vom Bureau of Fisheries (Washington) herausgegeben.

Mit einer kurzen Übersicht über die Temperatur und ihren Einfluss auf die Einwanderung der Lachse in Flüsse und das Springen in Wasserfälle schliesst das inhaltreiche Buch. H. Henking.

D. Bhatia. On the production of annual zones in the scales of the rainbow trout (*Salmo irideus*) I. Journal of experimental Zoology. Vol. 59, No. 1. Philadelphia, Pa., 1931.

Den Einfluss von Temperatur und Ernährung auf die Bildung der Sommer- und Winterringe hat der Autor an den Schuppen der Regenbogenforelle experimentell geprüft. Die vorliegende Veröffentlichung befasst sich mit der Einwirkung der Ernährung, eine zweite, die Temperatur behandelnd, soll folgen. Zur Durchführung der Experimente wurden 100.000 Forelleneier mit der Milch eines einzigen Männchens befruchtet und die ausschlüpfenden Larven, nach Resorbierung des Dottersackes, gleichmässig gefüttert. Überdies wurde eine Anzahl gleichgrosser einjähriger Tiere beschafft, von denen die eine Hälfte sehr reichlich Futter erhielt, während die andere hungerte.

Bei den jugendlichen Tieren begannen sich die Schuppen am 89. Lebenstage zu bilden. Zur Untersuchung gelangten nur normalgeformte aus einer kleinen Region hinter dem Kiemendeckel, indem sie mit dem Okularmikrometer gemessen, und die Zahl und Breite der auf ihnen sichtbaren Ringe festgestellt wurde. Da die aus dem Ei gezogenen Forellen stark auseinander wuchsen, mussten sie sehr bald nach Grössenklassen getrennt werden. Bei allen aber ist die Wachstumskurve eine gerade Linie. Die Schuppen der kleineren Tiere waren relativ länger als die der grossen und zeigten eine grössere Zahl von Ringen. Die Kurve, welche die Zahl der Ringe auf den Schuppen darstellt, zeigt, dass bei Beginn des Wachstumes eine grössere Zahl von Ringen geformt wird, und dass später diese Zahl ständig sinkt. Die Schuppe wächst also anfangs schneller als der Fisch, später langsamer. Da an den Schuppen dieser jugendlichen Forellen in der Zeit von Oktober bis Februar die Bildung von Winterringen nicht beobachtet werden konnte, nimmt der Autor an, dass die Temperatur keinen Einfluss auf deren Anlage hat. Eine Stütze seiner Annahme sieht er in der Bildung breiter Ringe auf den Schuppen reichlich gefütterter Tiere, während hungernde Forellen nur schmale Ringe formen. Dieser etwas einseitige Standpunkt darf keineswegs verallgemeinert werden, zumal eine Reihe von Befunden an Fischen europäischer Gewässer einen gewissen Einfluss der Temperatur nicht ausschliessen. H. L.

C. H. O'Donoghue and **E. M. Boyd.** A Preliminary Investigation of the Food of the Sea Trout (*Salmo trutta*). Fisheries, Scotland, Salmon Fish., 1930, No. III. Edinburgh 1931.

To many it will be very surprising that hitherto so little has been known about the food of one of our commonest migratory fishes, especially as the trout is one of the few that have any economic importance, and the authors of this paper are to be congratulated on the profitable line of research they have begun.

The material consisted of 19 stomachs from a marine habitat and 144 from an estuary. Of those taken in the sea all contained food and in all but one fishes were present, the commonest being the sand-eel (*Ammodytes*). Young Clupeoids and Gadoids and Crustacea were occasionally found.

The estuarine material was much more varied though a large proportion of the stomachs were empty, but the contents of those containing food ranged from purely marine material, such as *Ammodytes*, to such freshwater organisms as Ephemerid and Caddis nymphs. This point is important as it shows that the sea trout, unlike the salmon, does sometimes feed in fresh water and it is to be hoped the next paper will include data from fishes taken in rivers beyond the tidal limit.

It may be suggested that when dealing with estuarine material greater attention should be paid, wherever possible, to the identification of Gammarids. It is highly probable that besides *Gammarus locusta* and *G. pulex*, estuarine forms such as *G. duebenei* will be found.

The paper concludes with a useful series of tables giving the sex, number of pyloric caeca, food and parasites found in each fish.

In this preliminary account, the authors have wisely refrained from anticipating those generalisations which will be evident when the work is complete, an example which might be more widely followed.

F. T. K. Pentelow.

J. R. Norman. A History of Fishes. Ernest Benn. London, 1931.

Mr. J. R. Norman, assistant keeper for zoology British Museum (Natural History), vient de publier un intéressant ouvrage sur les Poissons, illustré de 9 planches et de 147 figures dans le texte qui a 463 pages. Il a été conduit à écrire ce livre pour répondre aux nombreuses questions qui lui sont posées sur la structure, les fonctions, la répartition géographique, l'origine des poissons de mer et d'eau douce. Il a entrepris cet ouvrage comme un magasin de faits précis, clairement exposés.

La définition des Poissons est établie de façon à en exclure une quantité d'êtres qui, en langue anglaise, sont qualifiés d'un nom double, dont le second est le mot fish, et qui n'ont rien à voir avec les Poissons véritables. Ces derniers sont des vertébrés caractérisés par leur vie aquatique et leur respiration branchiale. Leur nombre est plus grand que celui des autres vertébrés; on en connaît actuellement 20.000 espèces, et chaque année on en découvre une centaine de nouvelles.

L'auteur donne un rapide aperçu des variations de la forme chez les poissons, accompagné de figures démonstratives, ce qui l'amène à exposer

le mode de locomotion de ces animaux qui nagent selon trois méthodes différentes. Cette étude, fort difficile au point de vue mécanique, est exposée d'une façon claire qui a été facilitée par les notions fournies par le cinématographe.

L'étude de la fonction respiratoire, c'est-à-dire de la manière dont les poissons extraient l'Oxygène de l'eau, fait l'objet d'un chapitre contenant l'exposé de la structure et des variations de la branchie; celle-ci est considérée comme l'organe primitif de la respiration des Vertébrés qui a évolué vers le poumon chez les plus élevés, mais est restée, chez les Poissons, dans son état d'origine. L'anatomie comparée, le développement et la physiologie de la branchie sont exposés avec beaucoup de soin.

Les nageoires, la peau, les écailles, la bouche, les mâchoires, les dents forment la matière de trois chapitres importants car ils conduisent à la classification des Poissons en familles naturelles.

Les appareils venimeux, électriques, lumineux, auditifs, les viscères, sont traités d'après les découvertes les plus récentes. A signaler une intéressante étude des organes de la coloration.

Les conditions générales de la vie, qui varient tant, selon que les poissons habitent les eaux superficielles ou profondes, chaudes ou froides, éclairées ou obscures, douces ou salées, à fonds vaseux ou rocheux, expliquent la distribution géographique et la constitution des faunes, ainsi que les migrations des poissons qui recherchent pour se nourrir des aliments spéciaux, eux-mêmes dépendant des conditions spéciales des eaux, des localités pour se reproduire présentant des conditions physiques bien déterminées.

L'auteur prend divers exemples chez les *Clupeidæ*, *Gadidæ*, *Percidæ*, *Cyprinidæ*, etc.

Un chapitre important est consacré à la reproduction, aux œufs, à la ponte, à l'incubation, aux soins donnés aux jeunes par les parents, aux métamorphoses. Les découvertes du Dr. Johs. Schmidt sur l'Anguille sont exposées avec une grande clarté, ainsi que les transformations de la Plie.

Une étude intéressante est réservée aux Poissons fossiles, à leur répartition et à leurs apparitions successives dans les couches du globe, à leur origine, à l'étude des ancêtres les plus lointains des poissons actuels, à la reconstitution des formes disparues.

Les Poissons fournissent à l'homme une matière alimentaire de premier ordre. La dernière partie du livre de Mr. Norman est consacrée à l'étude des Poissons au point de vue commercial, à la pêche, aux conserves, aux produits accessoires, huiles, colles, engrais, etc. Ce chapitre est très important.

Un curieux chapitre est réservé aux légendes relatives aux Poissons, aux productions artistiques qui les représentent.

Le livre de Mr. Norman doit avoir sa place dans les bibliothèques des naturalistes, des laboratoires, des Universités et aussi des industriels de la pêche qui ont tout à gagner à connaître avec précision les êtres dont ils tirent leur profit.

L. Joubin.

M. Newbigin. Life by the Seashore; an Introduction to Natural History. Rewritten and revised by R. Elmhirst. George Allen & Unwin. London, 1931.

It is thirty years since this most useful book was first published, and it has been the constant companion of many naturalists. A new edition is most welcome and in it are to be found several alterations and additions most of which are decided improvements. Although the bulk of the work remains the same the opening chapters have been rewritten and a new chapter (a very useful one) on sea-weeds added. The keys for the identification of the species have been extended and the nomenclature brought more up to date, most of it being standardised by the recent new edition of the Fauna List of the Marine Biological Association of the United Kingdom. The figures of the old edition, which were mostly excellent (the only exception being the ctenophore, figure 23 on Plate VI), have been retained but instead of being scattered in the text with the descriptions below are now arranged on plates. The descriptions of the figures on the plates are far away at the beginning of the book — an innovation which is decidedly awkward.

However, there is very little to criticise, for the book is still the delightful companion that it always has been and much the best of the works on seashore life so far offered to us. We are all grateful to Mr. Elmhirst for taking it in hand and bringing it up to date so successfully whilst altering so little. M. V. L.

L. Roule. Les poissons et le monde vivant des eaux. IV. Les œufs et les nids. Librairie Delagrave. Paris, 1931.

The fourth volume of a voluminous work bearing the sub-title "Études Ichthyologiques et Philosophiques", to be completed in nine volumes, deals with eggs and nests. It is adequately described by a statement in the author's preface that the volume might bear two sub-titles, both equally appropriate — "Souvenirs of an embryologist" and "The book of generation" — for it has the discursiveness to be expected of the former and the universality to be looked for in the latter. Fishes merely form the peg upon which to hang a varied assortment of materials from the whole of the animal kingdom. A list of chapter headings indicates the range of the "Souvenirs". — Floating eggs, and their nurse, the Sea; Fecundity; Destruction of alevins; Cannibalism; Courtship of lampreys; Nuptials of the shad; Eggs-attached, and suspended; Hatching ponds (carp); Egg ribbons (perch and others); Egg masses which are guarded; Nests of the sticklebacks; Nests made of vegetation; Nests made of bubbles; The bitterling and the pond mussel; Incubation of eggs by various organs or parts of the body; The nuptial dance of the sea-horses; The practice of "Couvade" in the sea-horses; Marsupialism; Viviparous females; Degenerate males; Crocodiles and maternal affection!

The text is accurate, though popular in its style, and perhaps too highly coloured. Whilst it may interest, it is not primarily intended for the expert. There are 16 vividly coloured plates and numerous original figures in the text. H. O. Bull.

A. E. Hopkins. Temperature and the Shell Movements of Oysters. U. S. Department of Commerce, Bulletin of the Bureau of Fisheries, Vol. XLVII, No. 1. Washington, 1931.

From the consideration of data furnished by a series of kymographic records, extending over periods of from five to thirty days, of the shell movements of oysters together with parallel thermographic records of the temperature of the stream of sea water in which the oysters were immersed, the author of the publication under notice puts forward several points of interest in connexion with the influence of temperature on the opening and closing of the valves of the oyster. The kymographic records considered are, for the most part, those relating to the behaviour of the Olympia oyster (*Ostrea lurida*). Such data as are available with regard to the Eastern Oyster (*Ostrea virginica*) are, however, presented for comparison.

Evidence was afforded by the autographic records that at temperatures falling for the most part within the range 14°—17° C., the oysters were open on the average for slightly more than 20 hours per day — a figure conforming closely to that previously obtained by NELSON. The very gradual fall in the average daily temperature from 10° C. to 5° C. over a period of 20 days resulted in the reduction of the average number of hours per day during which the oysters were open from something over 20 at 10° C. to 15 at 5° C. It is noteworthy that at the latter temperature, not infrequently referred to in American oyster litterature as the hibernating temperature, the valves were not continually closed.

The contrast between the comparatively slight effect on the average number of hours open per day of the gradual temperature drop just referred to, and the results obtained in another experiment, in which several marked fluctuations in the water temperature occurred, suggested that it is change of temperature rather than the degree of temperature itself which influences the length of time during which oysters remain open.

Data obtained in subsequent experiments led to the conclusion that it is the rapidity of the temperature change which determines the oyster's reaction to temperature, a rise causing it to open, a fall causing it to close, and furthermore that oysters are most sensitive to temperature changes at 5° C., this sensitivity diminishing with rise of temperature until, at 14°—17° C., scarcely any effect upon the number of hours open per day is noticeable. H. M. W.

Thurlow C. Nelson and **Earle B. Perkins.** Studies of the Movements and of the Distribution of Oyster Larvae in Natural Waters of New Jersey, and a Study of Oyster Problems in Barnegat Bay. Annual Report of the Department of Biology, (Bulletin 522). New Jersey Agricultural Experiment Station, New Brunswick, N. J. 1931.

In a paper by KÄNDLER (recently reviewed in this Journal[1]) mention is made of the explanation offered by Prof. NELSON to account for the movement of the older larvae of *Ostrea virginica* towards headwaters and away from the open sea, namely, that they remain on the bottom during ebb, but rise and are carried along during flood periods of the tide. This

[1]) Journal du Conseil, V, 2, 1930, p. 267.

was regarded with scepticism, for it appeared to demand a faculty in the larvae for distinguishing between ebb and flood water movements, and acting accordingly. The present paper summarises the results of six years investigations in Barnegat and Delaware Bays by NELSON on the vertical distribution of oyster larvae and salinities.

The behaviour of larvae previously described is largely confirmed, and an explanatory hypothesis is suggested, which is supported by laboratory observations also with larvae well advanced in development. Briefly, a decrease in swimming activity by older larvae while in still water has been noted. This tends to concentrate them on the bottom during slack water, and in eddies, backwaters, or quiet basins. On the other hand, a current flowing past them causes a marked increase in the activity of the velum, so that they rise from the bottom and are carried along. They show a reaction to changes in salinity also, not in seeking actively any particular layer, but in this way; increased activity of the velum follows an abrupt change to higher salinity, but lowered salinity is followed by subdued action of the velum. At the mouths of rivers and creeks, where brackish and salt water meet, and where oysters occur naturally, there is a tendency for greater activity of larvae on the flood than on the ebb tide. Differences in these observations from the findings of PRYTHERCH[1]) in Milford Harbour are discussed in this paper, and the method of formation of a sharp salinity gradient, termed a halicline, is described. Such a discontinuity layer, just above which oyster larvae tend to congregate, is a feature of Barnegat Bay. Current-meter observations show that the layer of higher salinity water entering the bay during flood tides may move in the opposite direction to that of the overlying water, or may remain still, or the whole may move together. In the case last mentioned, the larvae are then carried along and concentrated at the level where the current is fastest, independently of the halicline. The importance of the purely mechanical effect of the current is emphasised by Dr. PERKINS, who in 1929 undertook the observations in Barnegat Bay. His vertical samples were taken at intervals no greater than 0.2 metres. There is no indication of larvae moving to an optimum salinity layer; they are distributed purely passively, their ciliary activity being limited to raising them into the current.

An interesting suggestion is made by the second author regarding the failure of a commercial set of spat for the fifth year in succession in Barnegat Bay; namely, the artificial selection of unfit stunted oysters for breeding, by the removal of healthy fast-growing individuals for market, thereby resulting in a weakened stock.

This report contains a considerable amount of data, clearly presented in diagrammatic form and summarised, and the observations are of undoubted interest both to the hydrographer as well as to the biologist. It is understood that further intensive vertical sampling is contemplated, with the aid of a multiple water and plankton sampler, and possibly a multiple recording current meter. It is good to know that the long series of observations begun by JULIUS NELSON, and taken up by his son, will be continued, and further reports will be awaited with interest. H. P. S.

[1]) Reviewed in Journal du Conseil, V. II, 1930, p. 267.

Current Bibliography.

Prepared by the Editor with the assistance of Miss THURSBY-PELHAM.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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A Guide to Fish Marks

used by Members of the

International Council for the Exploration of the Sea,

and by some non-participant Countries.

Published by Order of the Council, in accordance with Recommendation 5 of the Editorial Committee (30th May, 1930) (Rapp. et Proc. Verb. Vol. LXVI. Copenhague, 1930, p. 76).

Instructions for using the Guide.

On page 134 will be found an alphabetical list of the distinguishing letters (**E, D** etc.) engraved on the fish marks. Against each letter are given the nationality of the institution issuing the mark and a reference to the appropriate page of the pamphlet. Pages 136—165 comprise the body of the guide; they are arranged according to nationality; similar marks used by different institutions are described separately[1]). In order to identify the source of a mark look first for the distinguishing letters on page 134, where a reference to the appropriate section of the pamphlet will be found. There a drawing of the mark is given with all necessary details on the same page.

Finally, on page 135 is given, for convenient reference, the name and address of at least one institution which deals with marked fish in each country.

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[1]) The schedule followed by Dr. Hertling in forwarding the German information has been adopted as standard.

List of distinguishing letters to be found on fish marks, with nationality of marking institution and page reference.

		Pages
B	United States of America	165
	Poland	156
D	Germany	142, 147
	Scotland	161
DA or Da	Denmark	137
DF	Germany	145
DFV	Germany	148
DH	Germany	143, 144
DHb	Germany	146
E	England	138
EB, ED, EE etc.	England	138
F	Canada	136
	Finland	141
FD	Germany	148
H or HV	Germany	146
I.F.S	Irish Free State	151
L	Latvia	152
	England	140
N (N1, N2)	Norway	153, 154
Nb	Germany	145
O	Germany	150
⊖	Germany	149
P	Poland	155, 156
P with T	Poland	157
PH	England	139
RHH	Russia	158
RI'OH	Russia	158
S	Sweden	163
Sa, Sb etc.	Scotland (see footnote to page)	161
SV or Sv	Sweden	162
SC or Sc	Scotland	159, 160, 161
SF	Finland	141
	Scotland	161
U.S.B.F	United States of America	164, 165
U.S.S.R	Russia	158
No letter	Scotland	160
	Canada	136

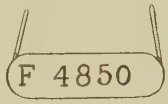
The Principal Offices for receiving particulars of marked fish, including foreign-marked; at least one address in each country. (For alternative addresses within each country, see pages dealing with individual marks).

Belgium	Laboratoire Maritime, Ostende-Phare, Ostende.
Canada	Atlantic Biological Station, St. Andrew's, N. B.
Denmark	Dansk Biologisk Station, Strandvej 34 B, Hellerup, København.
Finland	Bureau for Fishery Investigations, (Kalataloudellinen Tutkimustoimisto) Helsingfors.
France	Office Scientifique et Technique des Pêches Maritimes, 3 Avenue Octave Gréard, Paris.
Germany	Staatliche Biologische Anstalt, Helgoland.
	Zoologisches Staatsinstitut und Museum, Fischereibiologische Abteilung, Hamburg.
Germany	Deutscher Seefischerei-Verein, Potsdamerstrasse 22 a, Berlin W 9.
	Deutscher Fischerei-Verein, Prinz Albrechtstr. 3, Berlin SW 11.
Great Britain	Ministry of Agriculture and Fisheries, Fisheries Laboratory, Lowestoft.
	Fishery Board for Scotland, Wood Street, Torry, Aberdeen.
Holland	Rijksinstituut voor Biologisch Visscherijonderzoek, Binnenhof 4, 's Gravenhage.
Irish Free State	Department of Lands and Fisheries, 3, Kildare Place, Dublin.
Italy	R. Laboratorio Centrale di Idrobiologia, Piazza Borghese 91, Roma.
Latvia	Fishery Laboratory (Zvejniecibas Laboratorija), Kalpaka bulv. 6, Riga.
Norway	Fiskeridirektøren, Postboks 226, Bergen.
Poland	Sea Fisheries Office (Morski Urzad Rybacki), Gdynia.
	Laboratory for Fisheries (Pracownia Rybacka), Zacisze 8, Bydgoszcz.
Portugal	Aquario Vasco da Gama, Dafundo.
Russia (U.S.S.R.)	State Oceanographical Institute, 6 Herzen Street, Moscow.
Spain	Instituto de Oceanografiá, Alcalá 31, Madrid.
Sweden	Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.
United States of America	Department of Commerce, Bureau of Fisheries, Washington, D. C.

CANADA

Marking Institution Department of Fisheries, Ottawa.
Type Small silver tag with two pins attached. Stamped **F** and a number.

Figure

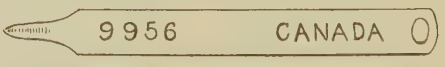


Use **Salmon.**
The tag is fastened to the dorsal fin.

Scale of Reward On reporting the capture of a marked Salmon and returning the tag with record of weight, length, condition (fresh run or kelt), date, method and place of capture, and about three dozen scales from the left side of the middle of the body of recaptured Salmon ..... 1.00 Dollar

Reception Office Department of Fisheries, Ottawa; or the nearest Dominion Fishery Officer.

Marking Institution Biological Board of Canada, Toronto 5.
Type (a) One smaller pointed strip of metal plate. Stamped **Canada** and a number.
(b) One pointed strip of metal plate stamped with a number only.



Figure

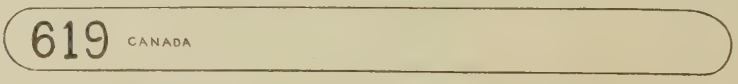
Use **Cod, Haddock, Pollack** (*Gadus virens*), **Salmon** and **Lobsters.**
When in use these metal tags are bent so that the point passes through a fin and the hole in the other end and clinches.
They are usually placed on the dorsal side of the base of the tail.

Scale of Reward For tags and information..... 25 cents

Reception Office Atlantic Biological Station, St. Andrew's, N. B.

Marking Institution Biological Board of Canada, Toronto 5.
Type (a) One white strip of celluloid.
(b) One pink strip of celluloid.
Both stamped **Canada** and a number.

Figure



Use **Mackerel.**
When in use these strips are curled to form a ring about the base of the tail.

Scale of Reward For tags and information..... 25 cents

Reception Office Atlantic Biological Station, St. Andrew's, N. B.

DENMARK

Marking Institution Dansk Biologisk Station, Hellerup, København, and Komm. f. Danmarks Fiskeri- og Havundersøgelser.

Type Two ebonite discs attached by a silver wire.
One stamped **DA 29** (indicating the year) and a number.

Figure

Use **Cod, Plaice, Flounder** and other **flatfish.**
The disc is fixed by thrusting the silver wire between the interradii of the dorsal fin of the flatfish. In Cod the disc is fixed in the centre of the gill-cover, between the opercular bones.

Scale of Reward For each recaptured fish with full information regarding place and date of capture.. Kr. 2.00
The market value of the fish is also paid.

Reception Office Dansk Biologisk Station, Strandvej 34 B, Hellerup, København.

Marking Institution Dansk Biologisk Station, Hellerup, København and Komm. f. Danmarks Fiskeri- og Havundersøgelser.

Type One narrow silver safety-pin hook.
Stamped **Da** and a number.

Figure

Use **Salmon** and **Trout.**
The mark is attached in front of the first dorsal fin.

Scale of Reward For each recaptured fish..... Kr. 2 to 5
The market value of the fish is also paid.

Reception Office Dansk Biologisk Station, Strandvej 34 B, Hellerup, København.

Marking Institution Dansk Biologisk Station, Hellerup, København, and Komm. f. Danmarks Fiskeri- og Havundersøgelser.

Type One narrow silver ring with plate.
Stamped **Da** and a number.

Figure

Use Young **Cod, Salmon** and **Trout.**
The mark is attached as above.

Scale of Reward For each recaptured fish ..... Kr. 1 to 5.

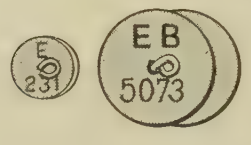
Reception Office Dansk Biologisk Station, Strandvej 34 B, Hellerup, København.

ENGLAND

Marking Institution Ministry of Agriculture & Fisheries, London.

Type
(a) Two ebonite discs, attached by a silver wire. One disc stamped **E** and a number.
(b) Two discs as (a). One disc stamped **E** and a second letter, with a number below.
(c) Two smaller ebonite discs, attached by a silver pin. One black, stamped **E** and a number, the other red, unstamped.

Figure



Use
(a) **Cod.**
(b) **Plaice.**
(c) **Hake.**

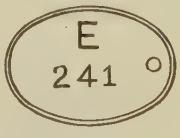
Scale of Reward
For the fish and mark, with information as to date and place of capture 2/-
For the mark alone, with the same information .. 1/-
For the mark alone, without information ..... 6d.
Market price will be paid in addition to the reward, market price being such as the collector judges to prevail on the day of landing the fish. The finder is informed of date and place of liberation.

Reception Office Director, Fisheries Laboratory, Lowestoft,
or the Ministry's local Fishery Officer or Collector.

Marking Institution Ministry of Agriculture & Fisheries, London.

Type
Oval copper disc.
Stamped **E** and a number.

Figure



Use
Crabs.
Mark attached by a copper wire to one of the large claws of the Crab.

Scale of Reward
For Crab, mark and particulars as to date and place of capture, depth of water and gear used .. 2/-
For mark only with full particulars of capture 1/-
For mark without particulars ..... 6d.
Postage and market value of Crab are also paid. The finder is informed of date and place of liberation.

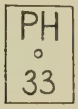
Reception Office Director, Fisheries Laboratory, Lowestoft,
or The Ministry's local Fishery Officer or Collector.

ENGLAND

Marking Institution Marine Biological Association of the United Kingdom, Plymouth.

Type Two vulcanite plates, the upper one being white and round or rectangular in shape (slightly modified from the ordinary type of plaice mark).
Upper plate stamped **PH** and a number.

Figure



Use **Rays** and **Skates.**
The mark is attached to the wing or tail of the fish.

Scale of Reward For fish or tail with mark in position, together with the following information; width measured across the wings to nearest $^1/_4$ inch or 0.5 cm.; locality where captured, and date of capture 2/-
For mark only with above information..... 1/-
For tail and mark only, or mark only ..... 6d.
Postage is refunded. The finder is informed of date and place of liberation.

Reception Office Director, The Laboratory, Citadel Hill, Plymouth.

Marking Institution Marine Biological Association of the United Kingdom, Plymouth.

Type One silver disc attached by a silver wire.
Stamped **PH** and a number.

Figure

Use **Rays** and **Skates.**
The mark is attached to the tail of the fish.

Scale of Reward For tail, with mark in position, together with the following information; width measured across the wings to nearest $^1/_4$ inch or 0.5 cm.; locality where captured, and date of capture 2/-
For mark only, with above information 1/-
For tail and mark only, or mark only ..... 6d.
Postage is refunded. The finder is informed of date and place of liberation.

Reception Office Director, The Laboratory, Citadel Hill, Plymouth.

ENGLAND

Marking Institution Lancashire & Western Sea Fisheries Committee, Preston.
Type Two black ebonite discs joined by a silver wire. One stamped **L** and a number.

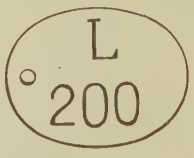
Figure

Use **Plaice.**
Scale of Reward For the mark, fish and information as to place and date of capture ..... 1/6 d.
For the mark alone, with the same information 1/-
For the mark alone, without information..... 6d.
In addition to rewards, the postage and the market price of the fish will be paid.
Reception Office All rewards will be paid from 16, Walton's Parade, Preston.

Addresses of persons entitled to receive fish:—
Mr. J. Eccles, 46, Egerton Street, New Brighton.
Mr. J. T. Bagot, 10, St. Bernard's Road, Knott End.
Mr. J. Huxley Hughes, 4, Newborough Street, Carnarvon.
Mr. E. Gardner, 34, Clark Street, Morecambe.

Marking Institution Lancashire & Western Sea Fisheries Committee, Preston.
Type One oval copper disc. Stamped **L** and a number.

Figure



Use **Crabs.**
Mark attached to the claw of the Crab by means of a copper wire.
Scale of Reward For the Crab, mark and information as to place and date of capture ..... 1/6 d.
For the mark alone, with the above information 1/-
For the mark alone, without information.. 6d.
In addition to these rewards, the postage and market value of the Crab will be paid.
Reception Office All rewards will be paid from 16, Walton's Parade, Preston.

Addresses of persons entitled to receive crabs:—
Mr. J. Eccles, 46, Egerton Street, New Brighton.
Mr. J. T. Bagot, 10, St. Bernard's Road, Knott End.
Mr. J. Huxley Hughes, 4, Newborough Street, Carnarvon.
Mr. E. Gardner, 34, Clark Street, Morecambe.
Mr. John Williams, Moorings, Aberdovey.
Mr. J. H. Fish, 1, Picton Terrace, New Quay, Cardigan.

FINLAND

Marking Institution Bureau for Fishery Investigations (Kalataloudellincn Tutkimustoimisto), Helsingfors.

Type Small oval silvered disc and pins.
Stamped **SF** and a number.

Figure

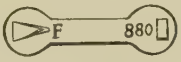
Use **Salmon** and **Lake Trout.**
Salmon principally in the Kemi-River, Lake Trout in the lake system of Saimaa and Päijänne, *Salmo salvelinus* in Ladoga.
The marks are attached to the second dorsal fin.
Pike. Marked in the coastal waters of the Gulf of Finland. The marks are attached to the dorsal fin.

Scale of Reward For each mark returned ..... 20—25 Finn. Mks.

Reception Office Bureau for Fishery Investigations, Helsingfors.

Marking Institution Bureau for Fishery Investigations (Kalataloudellinen Tutkimustoimisto), Helsingfors.

Type Narrow dumb-bell shaped silvered tag with a pointed fastener at one end and a hole at the other.
Stamped **F** and a number.

Figure 

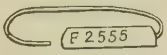
Use Young **Salmon.**
Principally in Kokemäki-River.
The mark is attached to the forward edge of the dorsal fin.

Scale of Reward For each mark returned ..... 20—25 Finn. Mks.

Reception Office Bureau for Fishery Investigations, Helsingfors.

Marking Institution Bureau for Fishery Investigations (Kalataloudellinen Tutkimustoimisto), Helsingfors.

Type Very small narrow silvered tag and pin.
Stamped **F** and a number.

Figure 

Use Young **Salmon.**
Principally in Kokemäki River.
The mark is attached to the forward edge of the dorsal fin.

Scale of Reward For each mark returned ..... 20—25 Finn. Mks.

Reception Office Bureau for Fishery Investigations, Helsingfors.

GERMANY

Marking Institution Deutsche Wissenschaftliche Kommission für Meeresforschung, Potsdamerstr. 22 a, Berlin W. 9.

Type Aluminium disc with 2 holes and silver wire. Stamped **D** and a number.

Note: The metal disc may fall off. The marking then remains recognisable by the form and thickness of the silver wire.

Figure

Use **Trout** released in the Baltic off Kolberg in April, 1930. The mark is secured at the front of the dorsal fin by a silver wire.

Literature: Mitteilungen des Deutschen Seefischerei-Vereins, Bd. XXXXVI. S. 100 and S. 224, 1930.

Scale of Reward

(a) On forwarding the whole fish with the mark and information as to place and date of capture, and gear ..... 3 RM. The market value of the fish is also paid.

(b) On forwarding the mark alone with the above information ..... 1.50 RM.

Reception Office

(1) Fishery Associations.

(2) State Fishery Officials.

(3) Deutscher Seefischerei-Verein, Prinz Albrechtstr. 3 Berlin SW. 11.

GERMANY

Marking Institution Staatliche Biologische Anstalt, Helgoland and Deutsche Wissenschaftliche Kommission für Meeresforschung, Abt. Ostsee.

Type The plaice mark of Heincke and Bolau, in the shape of a collar stud of black vulcanised rubber (ebonite) with a ring of soft rubber.
Stamped **DH** and two numbers.

Figure

Use **Plaice, Flounders** and other **flatfish** (occasionally **Rays).**
The mark is fastened, in the case of flatfish, between the dorsal fin-rays of the tail; in the case of Rays, on the pectoral fins.
Literature: Wissenschaftliche Meeresuntersuchungen. Neue Folge. Abteilung Helgoland. VII. Band, Heft 1, S. 71—78. 1905.

Scale of Reward
(a) On forwarding a fish with mark and information as to place and date of capture, type of net, length and live weight of the fish..... 2.00 RM.
In the case of fish of commercial value the market price is also paid.
(b) On forwarding the mark and information under (a)..... 1.00 RM.
(c) On forwarding the mark alone ..... 0.50 RM.

Reception Office For recaptured fish bearing marks of this kind, for marks alone and for the information set out under (a):—
(1) Biologische Anstalt, Helgoland.
(2) Fischereibiologische Abt. des Zoolog. Staatsinstituts und Museums, Hamburg.
(3) Institut für Seefischerei, Wesermünde.
(4) Deutscher Seefischerei-Verein, Potsdamerstr. 22a, Berlin W. 9.
(5) State Fishery Officials.
(6) Inspectors' Offices at the fishery ports and fish markets.

GERMANY

Marking Institution Staatliche Biologische Anstalt, Helgoland.

Type So-called "Scottish" plaice mark consisting of two discs, made of black vulcanised rubber (ebonite) joined by a silver wire.
Stamped **DH** and a number.

Figure

Use Marking of **Gadidae.**
The mark is secured by pushing the silver wire through the dorsal muscular structure of the tail part.
Literature: Fishery Investigations, Series II, Volume XI. No. 4. 1928. p. 10. London, 1929.

Scale of Reward
(a) On forwarding a fish with mark and information as to the place and date of capture, type of net, length and live weight of the fish.. 2.00 RM. In the case of fish of commercial value the market price is also paid.
(b) On forwarding the mark and the other information under (a)..... 1.00 RM.
(c) On forwarding the mark alone ..... 0.50 RM.

Reception Office For recaptured fish bearing marks of this kind, for marks alone and for the information set out under (a):—
(1) Biologische Anstalt, Helgoland.
(2) Fischereibiologische Abt. des Zoolog. Staatsinstituts und Museums, Hamburg.
(3) Institut für Seefischerei, Wesermünde.
(4) Deutscher Seefischerei-Verein, Potsdamerstr. 22a, Berlin W. 9.
(5) State Fishery Officials.
(6) Inspectors' Offices at the fishery ports and fish markets.

GERMANY

Marking Institution Bayerische Biologische Versuchsanstalt für Fischerei, Veterinärstr. 6, München 2.

Type "Fima" mark of metal. (See Note on p. 146).
Stamped **Nb 1—9999** and **DF 1—9999.**

Figure

Use Marking of ***Barbus fluviatilis, Abramis brama, Abramis björkna, Scardinius erythrophthalmus, Squalius cephalus, Chondrostoma nasus, Esox lucius.***
The mark is secured to the dorsal or the caudal fin with the special "Fima" pliers.
Place of marking: The Bavarian part of the Danube and tributaries: Main near Aschaffenburg.
Literature: Allgemeine Fischereizeitung, 55. Jahrgang, Nr. 3, 1930.

Scale of Reward For the fish, mark and information .... 2.00 RM.
For the mark and information alone .... 1.00 RM.
In addition the cost of carriage and value of the fish are refunded.

Reception Office In Bavaria: Prof. Dr. L. Scheuring, Bayerische Biologische Versuchsanstalt für Fischerei, Veterinärstr. 6, München.
Herr van Douve, Fischergasse 2, Passau.
In Austria: Oberamtsrat Dr. Grubmüller, Regierung, Linz a. D.
Marked fish are to be sent immediately, as far as possible uninjured, to the nearest reception station with precise information as to time and place of capture, if possible with precise information as to the section of the river. If, in exceptional cases, the whole fish cannot be sent, the mark is to be sent and in addition to the information already mentioned, precise information as to species, length, weight and sex of the fish are to be added.

Remarks Fish marked on the Württemberg stretch of the Danube, in similar fashion, may be sent to Reg. Rat Dr. Kurt Smolian, Württembergische Landwirtschaftskammer, Marienstr. 33, Stuttgart.
Those marked on the Austrian stretch of the Danube, in similar fashion, from Obernzell to below Linz and in the Inn may be sent to: Professor Dr. P. Steinmann, Aarau, (Switzerland): further eastward to below Vienna: Professor Cerny, Giertel Nr. 3, Wien XVIII.
All these marking stations use signs on the marks different from those of the Bavarian Biological Research Institute.
It may here be remarked that the so-called "Fima" mark is apparently not particularly satisfactory.

GERMANY

The Chief Fishery Inspector for Inland Waters for the Province of Hannover (Oberpräsidium, Archivstr. 2, Hannover) intends to undertake marking various fish in the Weser area. (Mark **H** or **Hv** and number).

Young **Salmon** (*Salmo salar*) and certain **freshwater fish** will be marked. It is not yet settled what types of mark will be used. It is proposed to mark Salmon with silver wire and glass beads (Literature: Mitteilungen des Deutschen Seefischerei-Vereins, Bd. XXX, Nr. 9/12, 1914. S. 285—286).

Marking Institution	Fischereibiologische Abteilung des Zoologischen Staatsinstituts und Zoologischen Museums, Kirchenallée 47, Hamburg 5.
Type	The plaice mark of Heincke and Bolau, in the shape of a collar stud of black vulcanised rubber (ebonite) with a ring of soft rubber. Stamped **DHb** and a number.
Figure	See page 143.
Remarks	Marking has not been carried out recently. The same marks were used as by the Biological Institute of Helgoland.

Note to p. 145:—

Im letzten Jahre hat sich bei unseren Markierungen manches geändert. Wir zahlen jetzt Prämien für zurückgelieferte Fische und Marken, falls genaue Angaben über Fangort usw. beigegeben werden.

Ausserdem haben wir auf den Vorschlag von Prof. Steinmann, Aarau, neben der "Fima" noch verschiedenfarbige Gummimarken verwendet, die der Heinckeschen Schollenmarke [s. Figur, S. 143] ähnlich sind, aber aus Weichgummi bestehen. Sie werden durch ein mittels einer Lochzange in die Kiemendeckel gemachtes Loch gezogen und durch die Haltescheibe gesichert. 2 Grössen werden verwandt. Die kleineren Marken scheinen besser zu sein als die grösseren. Ein abschliessendes Urteil über die Güte der Gummimarken kann noch nicht gefällt werden, doch scheinen besonders für Fische über 300 g die Resultate bessere zu sein als bei der "Fima". Das Markieren mit den Gummimarken ist zeitraubender und erfordert mehr Geduld und Geschicklichkeit als die mit "Fima".

Andere Marken werden zur Zeit noch konstruiert und versuchsweise verwandt.

L. Scheuring.
Biologische Versuchsanstalt für Fischerei.
Bayern.

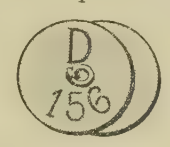
21. März 1932.

GERMANY

Marking Institution Deutscher Seefischerei-Verein, Potsdamerstr. 22a, Berlin W. 9.

Type So-called "Scottish" plaice mark consisting of two discs made of black vulcanised rubber (ebonite) joined by a silver wire.
Stamped **D** and a number.

Figure



Use Marking of North Sea **Plaice** transplanted to the Baltic.
Marks are secured by a silver wire which is passed through the fish below the dorsal fin.
Literature: Mitteilungen des Deutschen Seefischerei-Vereins, Bd. XXXXVI, S. 223, 1930.

Scale of Reward (a) On forwarding the whole fish with mark and information as to place and date of capture and gear ..... 2.00 RM.
In the case of larger fish whose market value exceeds 0.50 RM. the market price is paid also.
(b) On forwarding the mark alone with the above information ..... 1.00 RM.

Reception Office (1) Fishery Associations.
(2) Oberfischmeister Dr. Neubaur, Schloss, Kiel.
(3) Deutscher Seefischerei-Verein, Potsdamerstr. 22a, Berlin W. 9.

Remarks This mark has also been used for marking **Common Dabs** in the middle and western Baltic off Kolberg. The rewards are similar except that under (b) the length and weight of the fish is required and under (a) there is only a refund of 1.00 RM. for carriage and for packing in grease-proof paper with boracic powder. Reception Offices are as in (1) and (3) above and the Offices of the Fishery Inspectorate.
Literature: Mitteilungen des Deutschen Seefischerei-Vereins, Bd. XXXXVII. Nr. 1. 1931.

GERMANY

Marking Institution Deutscher Fischerei-Verein, Prinz Albrechtstr. 3, Berlin SW. 11.

Type Small silver spatulate plate.
Stamped **DFV** and a number.

Figure

Use Marking of **Eels** in the year 1912. The mark is fastened by the point being pushed through the skin of the Eel alongside the base of the dorsal fin.
Literature: Mitteilungen des Deutschen Seefischerei-Vereins, Band XXVIII, S. 205. 1912.

Scale of Reward (a) For an Eel with mark and information as to place and time of capture, length and weight of the Eel, the reward offered in 1912 amounted to..... 1.00 RM.
For larger Eels the market price was also paid.
(b) On forwarding the mark with incomplete information..... 0.75 RM.

Reception Office Deutscher Fischerei-Verein, Prinz Albrechtstr. 3, Berlin SW. 11.

GERMANY (DANZIG)

Marking Institution Westpreussischer Fischerei-Verein, Danzig.

Type "Scottish" plaice mark consisting of two discs made of vulcanised rubber (ebonite), each with 2 holes, fastened together by thick silver wire.
Stamped **FD** and a number.

Figure

Use Young **Sturgeon** (*Acipenser sturio*).
The wire is passed through the skin of the dorsal fin at the base of its front edge.
Literature: Flugblatt des Westpreussischen Fischerei-Vereins.

Scale of Reward On forwarding the mark with information as to the place and date of capture, length, and, if possible, the weight of the fish and address of the fisherman ..... 3 Gulden D. W.
If the captured marked Sturgeon is replaced alive, instead of the mark an official attestation of this action is sufficient.

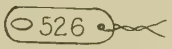
Reception Office Westpreussischer Fischerei-Verein, Schwarzes Meer 6, Danzig.

GERMANY

Marking Institution Fischerei-Institut der Universität, Königsberg i/Pr.

Type Silver mark of 1.5—1.7 cm. length and 0.5 cm. breadth (with 1 hole). Some of the silver marks are not bright but are blackened by a special process. Stamped ⊂ and a number.

Figure



Use Young **Salmon** (*Salmo salar*) and young **River Trout** (*Salmo fario*).

The mark is secured by means of a silver wire at the base of the dorsal fin.

Literature: Mitteilungen des Deutschen Seefischerei-Vereins, Bd. XXXXVI, Nr. 3. S. 101. 1930.

Scale of Reward

(a) On forwarding the whole fish with the mark and precise information as to the species of the fish, place of capture, length of fish from the tip of the nose to the end of the caudal fin, weight of the fish, sex, and about 20 scales from the side of the fish below the lateral line ..... 3.00 RM. The value of the fish and out-of-pocket expenses are refunded.

(b) On forwarding the mark alone with the above information ..... 1.50 RM.

Reception Office

(1) Fischerei-Institut der Universität, Tragheimer Kirchenstr. 74, Königsberg i/Pr.

(2) Deutscher Seefischerei-Verein, Potsdamerstr. 22a, Berlin W. 9.

GERMANY

Marking Institution Fischerei-Institut der Universität, Königsberg i/Pr.

Type Circular silver mark 1,3 cm. diameter.
Stamped **0** and a number.

Figure

Use Large **Salmon** (*Salmo salar*).
The mark is secured by a silver wire at the base of the dorsal fin.

Scale of Reward
(a) On forwarding the whole fish with mark and precise information as to the species of fish, place of capture, length of the fish from the tip of the nose to the end of the caudal fin, weight of the fish, sex and about 20 scales from the side of the fish below the lateral line..... 3.00 RM.
The value of the fish and out-of-pocket expenses are refunded.
(b) On forwarding the mark alone with the above information ..... 1.00 RM.

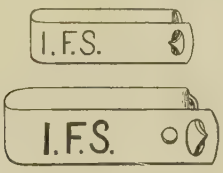
Reception Office
(1) Fischerei-Institut der Universität, Tragheimer Kirchenstr. 74, Königsberg i/Pr.
(2) Deutscher Seefischerei-Verein, Potsdamerstr. 22a, Berlin W. 9.

IRISH FREE STATE

Marking Institution Department of Lands and Fisheries, Dublin.

Type Strips of Monel metal with a point at one end and a hole at the other. Two sizes, used for large and small fish respectively.
Stamped **I.F.S.** and a number.

Figure



Use **Salmon.**

Scale of Reward For a label, with particulars of the marked fish recaptured..... 2/-

Reception Office Department of Lands and Fisheries, 3, Kildare Place, Dublin.

LATVIA

Marking Institution Ministry of Agriculture, Board of Fisheries and Pisciculture, Fishery Laboratory (Zvejniecibas Laboratorija), Riga.

Type Two ebonite discs, attached by a silver stud-pin, the head of which fits into a cavity in the plain disc.
One disc stamped **L** and a number.

Figure

Use **Flatfish.**

Scale of Reward For a mark..... 2 Lats (Gold francs)
The market price of the fish, if sent in, is also paid.

Reception Office Fishery Laboratory, Fishery Board of the Ministry of Agriculture, Kalpaka bulv. 6, Riga.

Marking Institution Ministry of Agriculture, Board of Fisheries and Pisciculture, Fishery Laboratory (Zvejniecibas Laboratorija), Riga.

Type Round oxidised-silver plate, usually attached by a thin silver wire.
Stamped **L** and a number.

Figure

Use **Salmon, Sea Trout, Eel** and **freshwater fish.**

Scale of Reward For a mark, with particulars of length and weight and some scales..... 5 Lats (Gold francs)

Reception Office Fishery Laboratory, Fishery Board of the Ministry of Agriculture, Kalpaka bulv. 6, Riga.

NORWAY

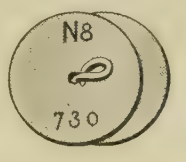
Marking Institution Fiskeridirektøren, Postboks 226, Bergen.
Type Two round silver discs attached by a silver pin. One disc stamped N and one or two numbers.

Figure

Use **Cod, Saithe** and **Halibut.**
Scale of Reward If the marked fish is sent or shown to a Fishery Officer, the local police or post office, etc. Kr. 2.50
The full value of the fish is also paid.
For the mark alone ..... Kr. 1.00
Postal expenses are refunded.
Reception Office Fiskeridirektoratet, Bergen; or local authorities.

Marking Institution Fiskeridirektøren, Postboks 226, Bergen.
Type Two ebonite discs attached by a silver pin. One disc stamped N and one or two numbers.

Figure



Use **Cod.**
Scale of Reward If the marked fish is sent or shown to a Fishery Officer, the local police or post office, etc. Kr. 2.50
The full value of the fish is also paid.
For the mark alone ..... Kr. 1.00
Postal expenses are refunded.
Reception Office Fiskeridirektoratet, Bergen; or local authorities.

NORWAY

Marking Institution Fiskeridirektøren, Postboks 226, Bergen.

Type Two Petersen discs; the upper one made of bone and brass, the lower one of bone. Attached by a silver pin twisted above the top disc.
The brass disc is stamped N and a number.

Figure

Use **Cod, Saithe,** and **Plaice.**

Scale of Reward If the marked fish is sent or shown to a Fishery Officer, the local police or post office, etc. Kr. 2.50
The full value of the fish is also paid.
For the mark alone ..... Kr. 1.00
Postal expenses are refunded.

Reception Office Fiskeridirektoratet, Bergen; or local authorities.

POLAND

Marking Institution Sea Fisheries Office (Morski Urzad Rybacki) Gdynia.

Type Two small ebonite discs of 16 mm. diameter. Stamped **P** and one or two numbers.

Figure

Use Adult flatfish: **Plaice, Common Dabs, Flounders.** Also to be used for **Turbot.** One disc is placed on each side of fish behind the dorsal fin, and connected by a silver wire passing through the muscles and bent on either side.

Scale of Reward For each mark from a flatfish Polish subjects are paid ..... 2 Zlotys
foreign subjects are paid..... 2 German Marks
The fish is also purchased at the ordinary market price.

Reception Office Sea Fisheries Office (Morski Urzad Rybacki), Gdynia.

POLAND

Marking Institution Sea Fisheries Office (Morski Urzad Rybacki) Gdynia.

Type A small silver plate 10 mm long and 5 mm wide with a sharp point at each end.
Stamped **P** and a number.

Figure

Use Young flatfish:— **Plaice, Common Dab,** and **Flounder.**
When used for marking, these points are bent and pushed through the muscles behind the dorsal fin.

Scale of Reward For each mark from a flatfish Polish subjects are paid ..... 2 Zlotys
foreign subjects are paid..... 2 German Marks
The fish is also purchased at the ordinary market price.

Reception Office Sea Fisheries Office, (Morski Urzad Rybacki), Gdynia.

Marking Institution Laboratory for Fisheries Zacisze 8, Bydgoszcz.

Type One small, black, oxidised hexagonal silver disc 12 mm long, and 8 mm wide.
Stamped **B** and a number.

Figure

Use Young **Salmon** (*Salmo salar*) and **Sea Trout** (*Salmo trutta*).
The mark is attached to the fish by means of a silver wire through the muscles before the dorsal fin.
These small marks are not at the present time in use, but were used three years ago.

Scale of Reward For each mark from a Salmon or Trout Polish subjects are paid..... 7 Zlotys
foreign subjects are paid..... 3 German Marks
The fish is also puchased at the ordinary market price.

Reception Office Laboratory for Fisheries, (Pracownia Rybacka) Zacisze 8, Bydgoszcz.

POLAND

Marking Institution Zoological Institute, The University, St. Anne 6, Krakow and Laboratory for Fisheries, Zacisze 8 Bydgoszcz.

Type One medium-sized oxidised hexagonal silver disc,, 14 mm long and 10 mm wide.
Stamped with a number and a letter **T** (meaning trout), also letter **P** below the numbers.

Figure

Use **Brook Trout** (*Salmo fario*).
The mark is attached to the fish by means of a silver wire through the muscles before the dorsal fin.

Scale of Reward For each mark from a Trout Polish subjects are paid ..... 7 Zlotys
foreign subjects are paid..... 3 German Marks
If the marked fish is brought it is purchased at the ordinary market price.

Reception Office Laboratory for Fisheries, (Pracownia Rybacka) Zacisze 8, Bydgoszcz.

Marking Institution Laboratory for Fisheries, Zacisze 8, Bydgoszcz.

Type One large black oxidised hexagonal silver disc, 15 mm long and 12 mm wide.
Stamped **P** and a number.

Figure

Use Young **Salmon** (*Salmo salar*) and **Sea Trout** (*Salmo trutta*).
The mark is attached to the fish by means of a silver wire through the muscles before the dorsal fin.

Scale of Reward For each mark from a Salmon or a Trout Polish subjects are paid..... 7 Zlotys
foreign subjects are paid..... 3 German Marks
If the marked fish is brought, it is purchased at the ordinary market price.

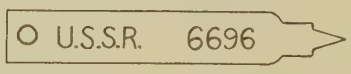
Reception Office Laboratory for Fisheries, (Pracownia Rybacka), Zacisze 8, Bydgoszcz.

RUSSIA

Marking Institution The State Oceanographical Institute, Moscow.

Type Silver strips with a sharp point at one end and a hole at the other.
Stamped **RMHII**; **RI'OII**; or **U.S.S.R.** and a number.

Figure



Use **Cod, Haddock, Coalfish, Catfish** (all three species), **Plaice, Halibut, Lesser** or **Greenland Halibut, Long Rough Dab, Greenland Shark, Starry Ray** (*R. radiata*).
The marks are fixed on the gill-covers.

Scale of Reward For marks and information regarding date, place and method of capture 2/6

Reception Office State Oceanographical Institute, Ver. Krasnosselskaja 17, Moscow, U.S.S.R.

SCOTLAND

Marking Institution Fishery Board for Scotland, Edinburgh.

Type Two ebonite discs attached by a silver wire.
One disc stamped Sc and a number, with a further number below.

Figure

Use **Plaice, Lemon Soles, Dabs, Halibut** and **Skate.**
(N. B. Skate may alternatively be marked by means of a lettered and numbered vulcanite stud with a retaining disc of rubber).

Scale of Reward
For fish and mark with full particulars of capture (i. e. position, date, type of gear in use). 2/-
For mark alone, with full particulars 1/-
For mark alone, without particulars ..... 6d.
The market value of fish received and the postal expenses incurred are also refunded.

Reception Office Scientific Superintendent, Marine Laboratory of the Fishery Board for Scotland, Wood Street, Torry, Aberdeen.

Note. As it is not the practice at present to forward a marked fish to the country of its origin when landed at a foreign port, the particulars required are — Length of fish from tip of mouth to end of caudal fin (and breadth in the case of Skate), weight (gutted or ungutted), sex and state of development of sexual organs. In the case of Plaice the otoliths of the fish are desired and for Lemon Sole a small sample of scales taken from the posterior third of the fish near the lateral line.

SCOTLAND

Marking Institution Fishery Board for Scotland, Edinburgh.

Type Small strip of silver plate with a wire attachment and rear plate of black ebonite. Silver plate stamped **SC** and a number.

(N. B. Some Scottish Haddock-marks consist of a silver disc or bar bearing a number and a vulcanite or red celluloid disc or bar which is fixed on the outside of the operculum while the silver plate is inside).

Figure

Use **Haddock.**

Scale of Reward

For fish and mark with full particulars of capture (i. e. position, date, type of gear in use).. 2/-

For mark alone, with full particulars 1/-

For mark alone, without particulars ..... 6d.

The market value of fish received and the postal expenses incurred are also refunded.

Reception Office Scientific Superintendent, Marine Laboratory of the Fishery Board for Scotland, Wood Street, Torry, Aberdeen.

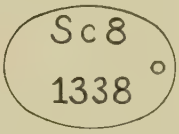
Note. As it is not the practice at present to forward a marked fish to the country of its origin when landed at a foreign port, the particulars required are — Length of fish from tip of mouth to end of caudal fin, weight, (gutted or ungutted), sex and state of development of sexual organs. In the case of Haddock a small sample of scales taken from the posterior third of the fish near the lateral line is desired.

SCOTLAND

Marking Institution Fishery Board for Scotland, Edinburgh.

Type Oval copper disc.
Stamped **Sc** and a number, with a further number below.

Figure



Use **Crabs** and **Lobsters.**
Mark attached to one large claw by a wire.

Scale of Reward For animal and mark with full particulars of capture (i. e. position, date, type of gear in use).. 2/-
For mark alone, with full particulars 1/-
For mark alone, without particulars ..... 6d.
The market value of the animal received and the postal expenses incurred are also refunded.

Reception Office Scientific Superintendent, Marine Laboratory of the Fishery Board for Scotland, Wood Street, Torry, Aberdeen.

Marking Institution Fishery Board for Scotland, Edinburgh.

Type Two types; both are small strips of silver plate with silver wire passing through.
One stamped **D** or **T** and a number and the smaller one bearing a number only.

Figure

Use **Salmon** and **Sea Trout.**

Scale of Reward For mark, date and place of capture, length and weight of fish, sex (if possible) and some scales:
Salmon 3/-
Sea Trout 2/-
A proportionate deduction may be made if any material details are lacking.

Reception Office Inspector of Salmon Fisheries of Scotland, 101 George Street, Edinburgh.

Note. As regards the marking of Salmon it was agreed at the meeting of the International Council in 1931, in deference to a request from Germany, that where the letter D is used, the letter on the new supplies of Salmon marks should be changed to Sa, Sb, etc.

SWEDEN

Marking Institution Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.
Type Upper disc, oval, cup-shaped, brass, attached by silver wire to a round bone disc on the lower side. Upper disc stamped **Sv** and two numbers.

Figure

Use **Plaice, Flounder** and **Turbot.**
The mark is fixed through the posterior part of the body.
Scale of Reward For each mark returned..... 2 Swedish crowns
Reception Office Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.

Marking Institution Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.
Type Small oval silver plate with two pins.
Stamped **SV** and a number.

Figure

Use **Cod.**
Fixed in the musculature behind the last dorsal fin.
Scale of Reward For each mark returned ..... 2 Swedish crowns
Reception Office Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.

Marking Institution Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.
Type Small oval silver plate mounted on a flat silver pin.
Stamped **SV** and a number.

Figure

Use **Eel.**
With a curved awl a hole is made at one side of the Eel under the anterior part of the dorsal fin and then the pin is inserted through this hole. Afterwards first the pin-end and then the plate are bent and pressed close to the body surface.
Scale of Reward For each mark returned ..... 2 Swedish crowns
Reception Office Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.

SWEDEN

Marking Institution Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.
Type Small strip of oxidized silver plate attached to a long thin silver wire.
Stamped S and a number.

Figure

Use Young **Salmon.**
The wire is passed through the front edge of the base of the dorsal fin and is then twisted upon itself, thus attaching the mark.
Scale of Reward For each mark returned ..... 2 Swedish crowns
Reception Office Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.

Marking Institution Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.
Type Small oval silver plate with two pins.
Stamped S and a number.

Figure

Use **Salmon.**
Mark is fixed to the adipose fin.
Scale of Reward For each mark returned ..... 2 Swedish crowns
Reception Office Kungl. Lantbruksstyrelsen, Fiskeribyrån, Stockholm.

UNITED STATES OF AMERICA

Marking Institution Department of Commerce, Bureau of Fisheries, Washington D. C.

Type Two celluloid discs attached by a nickel pin.
One inscribed **U.S.B.F.** and a number, and the other "Bureau of Fisheries, Washington D. C. Return both disks. Reward".

Figure

Use In 1930. **Weakfish** (*Cynoscion regalis*) and **Sea Bass** (*Centropristes striatus*).
In 1931. It is expected to use approximately 20,000 disc-tags on **Weakfish, Sea Bass, Striped Bass,** and possibly on **Cod, Haddock, Pollack** and **Flounder.**
This tag is attached to the caudal peduncle and a few to the operculum.

Scale of Reward For the return of tag with information as to time and place of capture and size of fish. 25 cents to 1 $

Reception Office Commissioner of Fisheries, Washington D. C.

Note: Use begun in the autumn of 1930. Several hundred Cod tagged, also a few Haddock and Pollack, with good results. This type will probably supplant the metal strap-tag, at least for the Cod.

UNITED STATES OF AMERICA

Marking Institution Department of Commerce, Bureau of Fisheries, Washington D. C.

Type Metal strap-tag.
Stamped **U.S.B.F.** and a number.

Figure

Use This mark has been used each year since 1923 (inclusive), for marking **Cod** along the New England coast and for **Salmon** in Alaska. Attached to the caudal peduncle.
This mark was also used on **Haddock** and **Pollack** (*Pollachius virens*). Several thousand **Mullet** were also marked.

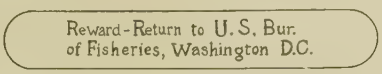
Scale of Reward For the return of tag with information as to time and place of capture, and size of fish..... 25 cents

Reception Office Commissioner of Fisheries, Washington D. C.

Marking Institution Department of Commerce, Bureau of Fisheries, Washington D. C.

Type Narrow strip of celluloid.
Inscribed **B** and a number on one side and "Reward — Return to U. S. Bureau of Fisheries, Washington D. C." on the other.

Figure



Use Tags of this type are inserted in the coelom, through a small incision.
Aquarium experiments over a six months period show that they are carried well and have little disturbing effect on growth.
600 **Weakfish** have been marked and a few **Cod.**

Scale of Reward For the return of tag with information as to time and place of capture and size of fish ..... 25 cents

Reception Office Commissioner of Fisheries, Washington D. C.

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